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The Emerging Economist

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ST. OLAF COLLEGE

The Emerging Economist

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Acknowledgements

St. Olaf College's chapter of Omicron Delta Epsilon is delighted to present the Spring 2023 edition of our in-house journal, *The Emerging Economist*. At our initial chapter meeting this year, this journal was simply an aspiration, and to see it come to fruition is extremely rewarding. This publication would not have been possible without the tireless efforts of our executive team, including President Rohan Silbaugh and Vice President Bergen Senf. We also extend our gratitude to the Economics Department at St. Olaf College for allowing this chapter to flourish and grow this past academic year. In particular, we would like to thank Michelle Potter-Bacon for her administrative support in helping to make this journal publication a reality.

We would also like to offer our congratulations to all senior Economics majors who have been awarded distinction this academic year. Your guidance, thoughtfulness, and willingness to lend a helping hand has not gone unnoticed, and we know that you will carry these attributes with you as you continue on to whatever comes next. The work you have done during your time at St. Olaf has been truly remarkable, and we are honored to be able to showcase some of that work here.

Thank you!

Hannah Peschel, *Co-Editor*
Benjamin Reinhard, *Co-Editor*

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Analyzing the Long-Run Equilibrium between Goods and Services Inflation

Rohan Silbaugh

I. Introduction

The years after the pandemic have been characterized by a marked spike in prices. General economic theory suggests that the current record inflation levels can be attributed to pent up demand via government issued economic stimulus checks, over stressed supply chains, and a shortage of oil resulting from the war in Ukraine. In his article *Wonking Out: Overheaters, Skewers, and the Non-linear Economy*, Paul Krugman discusses two factors to consider when addressing this rise in inflation: a sharp increase in aggregate demand after the pandemic and a sudden shift from demand for services to demand for goods. xThis piece raises the interesting question of how much of the current spike in inflation can be attributed solely to a shift in demand from services to goods, and how much of it results from an increase in aggregate demand.

If general overheating were to explain inflation, we would expect an aggregated inflation model to work just as well as an "inflation by parts" model considering goods and services separately. It seems to make more sense, however, that goods and services inflation are driven by different factors. Bryan and Myer (2010) find that services prices tend to be more sticky than goods prices, and thus are a factor of longer term inflation expectations. Peach et. al (2013) and Hargreaves et al. (2006) similarly found that goods prices are more volatile and subject to global economic conditions. If subtle but different factors truly drive goods and services inflation, we would expect a disaggregated model, looking at inflation for goods and services separately, to explain the current rise in inflation more accurately. Although goods and services inflation may change at different speeds and have different short term factors, Peach et. al (2004) suggests that there exists a long-run equilibrium between the goods and services price levels. In this paper, I use a VECM to exploit this long-run relationship and to gain insights into the speed of adjustment for goods and services inflation separately. I then use my model to forecast aggregate future inflation and my insights on the speed of adjustment to inform policy decisions moving into the new post-COVID economy.

II. Literature Review

There exists a sizable literature that has focused on goods and services inflation separately from which I build my analysis. Researchers first began to focus specifically on the distinct components of inflation to explain a global disinflationary surge in 2004. Bauer et al. (2004), Clark (2004), and Peach et al. (2004) focus on breaking down overall inflation into goods and services as well as more finely into major component types. More recently, Tallman et al. (2017), Peach et al. (2013), Hargreaves et al. (2006), and Bryan and Myer (2010) exploit Phillips Curve relationships to compare inflation forecasting results modeling goods and services separately to more traditional benchmark models.

Bauer et al (2004) calculated individual contributions to inflation with formulas considering both the change in price of a component and its overall weight in the aggregate. They found that during the period from 1995-2004 goods were actually negatively contributing to inflation. The major contributor to goods deflation in this period was shown to be used car parts, with medical service care and rent making up the majority of service contributions. Clark (2004) uncovered a similar trend in goods deflation in this period, specifically the widening of the gap between price indices for services and for goods. Clark explained this widening gap as largely due to the rising value of the US dollar and increased global competition. Clark (2004) correctly predicted that goods prices would rebound, although this would turn out to be temporary with further good deflation persisting in the decade following the great recession (Figure 1). This persisting gap gives merit to the work of Peach et. al (2004), who found that the goods and services PCE indices were cointegrated and estimated the equilibrium between these two series with a Vector Error Correction Model (VECM). Peach et. al (2004) predicted a goods and services system that would eventually return to equilibrium after a shock. My paper follows a similar model and estimates the current goods and services inflation response after the CPI spike.

Hargreaves et al. (2006) found that in New Zealand, measures of unemployment, specifically economic slack represented by the output gap, were a much better predictor of non-tradables (services) inflation, and annual present change in input prices was a better predictor of tradables (goods) inflation. This is consistent with the work of Clark (2004) that attributes goods deflation to the broader global economy and is a common theme in disaggregated inflation studies. Bryan and Myer (2010) broke down components of inflation not

into goods and services, but into sticky and flexible prices, with sticky prices defined as those changing less frequently than once every 4.3 months. In actuality, however, the majority of these sticky prices are services, and the flexible prices are mostly goods. They found that, as one would expect, long term inflation expectations were a better predictor of sticky prices while short term expectations were a better predictor of flexible prices. They also reinforced the idea that economic slack was a much better predictor of sticky prices than flexible prices. Building off this insight, Peach et. al (2013) created a more robust composite Phillips curve model, modeling services inflation on long-run (10-year) inflation expectations and a nonlinear employment gap term. They modeled goods inflation on lagged goods inflation, short term (1-year) inflation expectations, and lagged import price inflation less lagged goods inflation. They then multiplied the output of each model outcome by the relative weight of goods and services to create an overall forecast for inflation. I follow a similar procedure when aggregating my results. This combined goods and services model was then compared to a standard Phillips curve model of inflation. Forecasting MSEs were significantly improved in the goods and services model, with this composite approach tracking the post-2008 recession period much more accurately. Most recently, Tallman et al. (2017) utilized a state space model to forecast services inflation as a model of a random walk component, a stationary cyclical component, and a serially uncorrelated error term using a Bayesian Gibbs sampler. Tallman et al. (2017) used a parsimonious univariate model to predict goods inflation. They then combined these component forecasts in a similar fashion to Peach et. al (2013) and compared their results to successful forecasting model results in the Phillips curve literature. Tallman et al. (2017) found their inflation-by-parts model to perform between 5% and 23% percent better than these benchmark models.

This literature suggests that goods and services inflation may be driven by different factors, but potentially maintains an equilibrium relationship. In this paper, I take the approach of Peach et al. (2004) and estimate a VECM to predict the rebound of the goods and services equilibrium as well as aggregate inflation after the pandemic.

III. Data and Model

The inflation index I use for my analysis is the CPI All Urban Consumers from the Bureau of Labor Statistics. I collected the “Core CPI” series on a quarterly annualized scale,

excluding the more volatile food and energy components. I collected and calculated these inflation series for goods and services separately. I analyzed data from 1995 through the present, estimating my models from 1995 to 2007, testing them from 2010 to 2020, and forecasting from 2022 into the future. The quarter over quarter annualized inflation rate is depicted in Figure 1. (Figure 1):

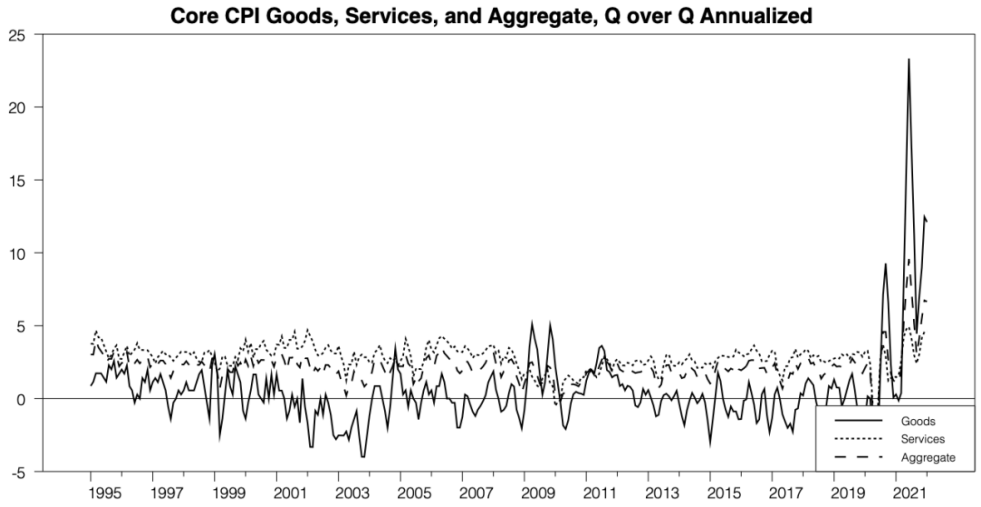


Figure 1 shows that the goods disinflationary trend discussed in Bauer et. al (2004) has persisted throughout the majority of the 21st century up until the pandemic. Services inflation has remained close to five percent, while goods prices have been remaining relatively stable, if not decreasing. One can also generally see a stable gap between the two series, with goods and services converging during recessions and diverging back to an apparent relationship during periods of economic expansion. It seems that this gives merit to Peach et. al (2004)'s results that indicate a long-run equilibrium relationship between goods and services inflation. These initial statistics encouraged a vector regression analysis similar to that of Peach et. al (2004).

In order to specify the appropriate model, I began my analysis by testing for stationarity in goods and services inflation using an augmented dicky fuller test. For both goods and services inflation, I failed to reject the null hypothesis and could not claim that they were stationary at the 10% level[1]. The literature and my data suggest a cointegrated relationship between these two variables. I verified this relationship using an Engle-Granger cointegration test, finding goods

[1] Goods Adf Results: *T-Statistic: -2.26066 (10% critical value: -2.57626)*
Services Adf Results: *T-Statistic: -2.38781 (10% critical value: -2.57626)*

and services inflation to be cointegrated at the 1% level[2]. These findings suggest that there is a long-run equilibrium relationship between goods and services inflation, and allowed me to estimate vector regression models including both the goods and services inflation series.

I started by estimating a Bayesian Vector Autoregression (BVAR) model of goods and services to examine causality patterns and dynamics of a two-variable system. I estimated my BVAR with four lags from quarter one of 1995 to quarter four of 2007. This BVAR is a system of equations with the following form:

(1):

$$\pi_G = \beta_{10} + \beta_{11}\pi_{G,t-1} + \beta_{12}\pi_{G,t-2} + \beta_{13}\pi_{G,t-3} + \beta_{14}\pi_{G,t-4} + \beta_{15}\pi_{S,t-1} + \beta_{16}\pi_{S,t-2} + \beta_{17}\pi_{S,t-3} + \beta_{18}\pi_{S,t-4} + \epsilon_t$$
$$\pi_S = \beta_{20} + \beta_{21}\pi_{G,t-1} + \beta_{22}\pi_{G,t-2} + \beta_{23}\pi_{G,t-3} + \beta_{24}\pi_{G,t-4} + \beta_{25}\pi_{S,t-1} + \beta_{26}\pi_{S,t-2} + \beta_{27}\pi_{S,t-3} + \beta_{28}\pi_{S,t-4} + \epsilon_t$$

Specifically π_G and π_S are quarter over quarter annualized inflation rates for goods and services respectively. These two dependent variables are regressed on a constant and 4 lags of each series. I estimated my coefficients using bayesian priors. The means of these bayesian prior distributions are all zero except for β_{11} and β_{25} which are estimated with a mean of 1. The distributions are normal except for the constant terms (β_{10} and β_{20}) which have a flat uniform distribution. I selected my standard deviations in accordance with the Minnesota Prior, namely incorporating tighter standard deviations [1] for the lags farther out and coefficients of non-dependent variable terms. I used a harmonic decay function with a decay value of 1 to tighten standard deviations for variables at farther out lag lengths. For my relative tightness, I used 0.5, indicating that non-dependent variable lags are estimated with priors that are half the size of those used for dependent variable lags.

To further exploit the apparent relationship between goods and services inflation, I then transformed my BVAR to a 3 lag VECM model over the same time period. Specifically, I exploit the following cointegrating equation:

(2):

$$\pi_{Gt} = \alpha + \beta\pi_{St} + \epsilon_t$$

[2] Engle Granger Cointegration Results: *T-Statistic: -5.07686** (1% critical value: -3.96273)*

This cointegrating equation is then used to construct the full form of my vector error correction model:

(3):

$$\Delta\pi_G = \beta_{10} + \lambda_{11}(\pi_{Gt-1} - \alpha - \beta\pi_{St-1}) + \beta_{12}\Delta\pi_{G,t-1} + \beta_{13}\Delta\pi_{G,t-2} + \beta_{14}\Delta\pi_{G,t-3} + \beta_{15}\Delta\pi_{S,t-1} + \beta_{16}\Delta\pi_{S,t-2} + \beta_{17}\Delta\pi_{S,t-3} + \epsilon_t$$

$$\Delta\pi_S = \beta_{20} + \lambda_{21}(\pi_{Gt-1} - \alpha - \beta\pi_{St-1}) + \beta_{22}\Delta\pi_{G,t-1} + \beta_{23}\Delta\pi_{G,t-2} + \beta_{24}\Delta\pi_{G,t-3} + \beta_{25}\Delta\pi_{S,t-1} + \beta_{26}\Delta\pi_{S,t-2} + \beta_{27}\Delta\pi_{S,t-3} + \epsilon_t$$

Estimating this VECM allows me to examine how my system reacts to shocks $(\pi_{Gt-1} - \alpha - \beta\pi_{St-1})$ in the long-run equilibrium between goods and services inflation. This shock variable can be interpreted as the error term in the cointegrating equation. The coefficients on the error correction term (ECT), namely λ_{11} and λ_{21}, represent the "Speed of Adjustment". The magnitude and sign of the speed of adjustment help predict the process by which goods and services inflation settles after a shock. I finish my analysis by forecasting inflation one year into the future and aggregating my results using the relative weights of goods and services inflation provided by the Bureau of Labor Statistics. These weights are updated biannually based on consumer expenditures. The most recent numbers in 2020 report 27.4% of core expenditures are attributed to goods and 72.6% of core expenditures are attributed to services.

IV. Empirical Results

The estimated 4 lag BVAR specified in equation 1 showed little causality between goods and services inflation. F-tests determining causality showed a resounding lack of evidence that goods inflation and services inflation granger cause one another[3]. The only significant variables in each equation are the first lags of the dependent variable (β_{11} and β_{25}). Although the system is stable and clearly returns to equilibrium after a shock, the impulse response functions were similarly inconclusive. A shock to goods inflation causes no significant change in services inflation, and a shock to goods inflation causes even less movement in services inflation (See Appendix). In both cases, the error bars include zero, so we can not make any conclusions about the dynamics of this system.

The VECM model allows for a little more useful interpretation. Both error correction terms are significant at the 5% level:

$\lambda_{11} =$ -0.295 ** $\lambda_{21} =$ 0.142**

(0.135) (0.059)

This indicates that when goods inflation was abnormally high in the previous quarter, it is corrected in the current period at an adjustment speed of negative 29.45%. Similarly, for services, the previous quarter's positive shock in goods inflation is corrected in the current period at an adjustment speed of positive 14.2%.

[3] F-Tests, Dependent Variable CORECPIGOODSQGA

Variable	F-Statistic	Signif
COREPIGOODSQGA	61.5892	0.0000000
CORECPISERVICESQ	0.0272	0.9985600

F-Tests, Dependent Variable CORECPISERVICESQ

Variable	F-Statistic	Signif
CORECPIGOODSQGA	0.2444	0.9126483
CORECPISERVICESQ	55.2748	0.0000000

After estimating my models, I tested forecasting performance along the period from 2010 quarter 1 to 2020 quarter 2.

BVAR Forecast Statistics for Goods Inflation

Step	Mean Error	Mean Abs Err	RMS Error	Theil U	N Obs
1	-0.1035298	0.5210515	0.6610637	0.8107	121
2	-0.2217532	0.8569745	1.0909665	0.8237	120
3	-0.3365191	1.1221083	1.4026478	0.8532	119
4	-0.3865546	1.1501020	1.4436995	0.8441	118
5	-0.3970256	1.1127130	1.4011546	0.8456	117
6	-0.3906424	1.0962356	1.3677314	0.8526	116
7	-0.4071712	1.1155955	1.3835148	0.8633	115
8	-0.4466918	1.1428536	1.4305353	0.8753	114

BVAR Forecast Statistics for Services Inflation

Step	Mean Error	Mean Abs Error	RMS Error	Theil U	N Obs
1	-0.0385114	0.2443413	0.3451585	0.9389	121
2	-0.0790310	0.3733229	0.5069227	0.9580	120
3	-0.1342928	0.4688319	0.6434967	0.9758	119
4	-0.1790796	0.4860635	0.6205264	0.9430	118
5	-0.2255225	0.4813097	0.6127504	0.9555	117
6	-0.2551535	0.4738779	0.6078110	0.9931	116
7	-0.2837702	0.4841232	0.6263854	1.0156	115

8	-0.3072227	0.5129943	0.6605324	1.0098	114

VECM Forecast Statistics for Goods Inflation

Step	Mean Error	Mean Abs Err	RMS Error	Theil U	N Obs
1	0.06252710	0.58347691	0.72460958	0.8886	121
2	0.11128275	0.95324203	1.15612975	0.8729	120
3	0.16406910	1.17543662	1.43596772	0.8735	119
4	0.19269856	1.18322212	1.45998229	0.8536	118
5	0.24662502	1.13508545	1.42232698	0.8584	117
6	0.29975254	1.09201313	1.39816996	0.8715	116
7	0.35676405	1.07624042	1.40828420	0.8788	115
8	0.39149391	1.05204008	1.43853514	0.8802	114

VECM Forecast Statistics for Services Inflation

Step	Mean Error	Mean Abs Err	RMS Error	Theil U	N Obs
1	-0.0250207	0.2394637	0.327412	0.8906	121
2	-0.0387828	0.3297078	0.4676817	0.8839	120
3	-0.0382991	0.4087067	0.5536401	0.8395	119
4	-0.0203404	0.4066701	0.5175462	0.7865	118
5	-0.0074851	0.4012295	0.5058752	0.7888	117
6	-0.0025555	0.4028894	0.5063269	0.8273	116
7	-0.0048962	0.4246479	0.5374954	0.8715	115
8	-0.0052719	0.4671769	0.5782334	0.8840	114

For both models, The mean absolute errors are significantly higher than the mean error, indicating that there is a good mix of over and underestimation in my forecast errors. That being said, the mean errors are lower at every step with the VECM model. The Theil U statistics indicate that the VECM is outperforming the BVAR for services inflation when comparing results to a naive forecast of no change. Since the VECM is further differencing the data, this is especially impressive, as the individual variables are not trending. The BVAR has slightly better Theil U statistics for goods inflation. However, given its high mean errors, this is probably just due to trends in the goods inflation series. The VECM appears to offer a more reliable prediction of future inflation by exploiting the equilibrium relationship between goods and services.

After testing forecasting performance on the period from 2010 to 2020, I looked towards the future to help inform the inflation debate. Using both my VECM and BVAR model, I forecasted both goods and services inflation out to September 2023 (Figures 2 and 3 respectively). I then use the BLS weights to re-aggregate the data and provide an overall prediction of future inflation. Below are the graphs of my forecasts for goods and services by model up until 2023. The aggregate inflation series was calculated from the respective weights of core goods (27.4%) and services (72.6%) published by the BLS.

Figure 2.

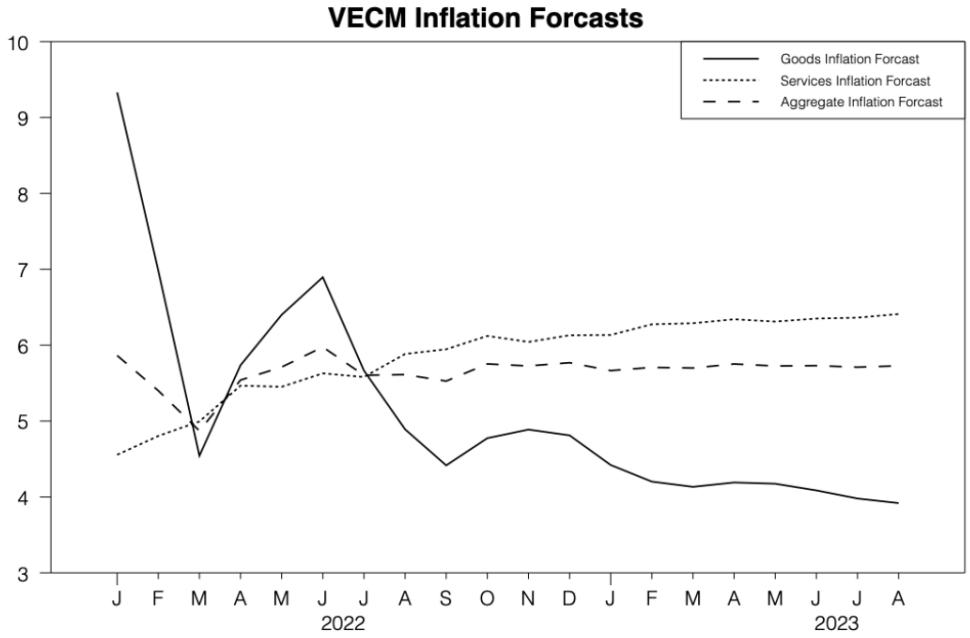
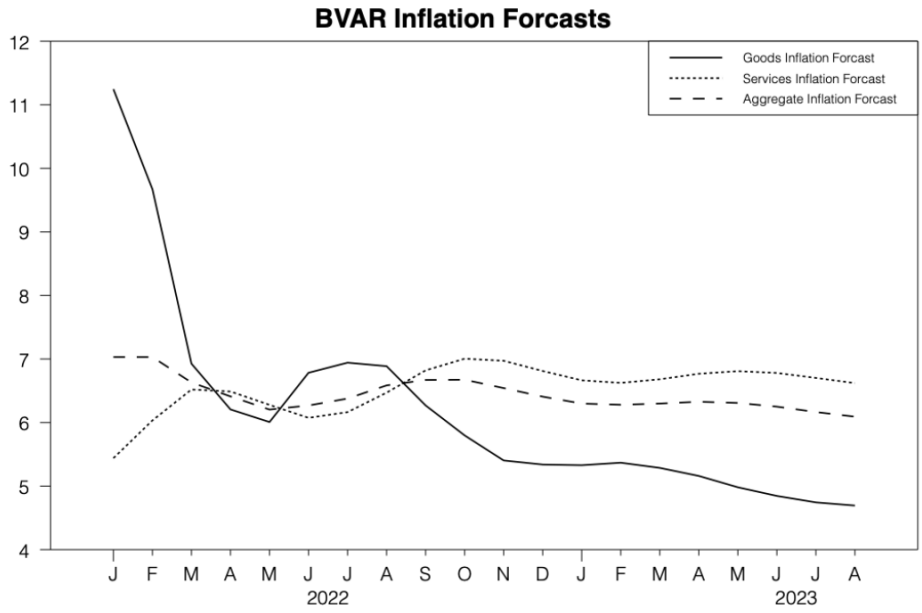
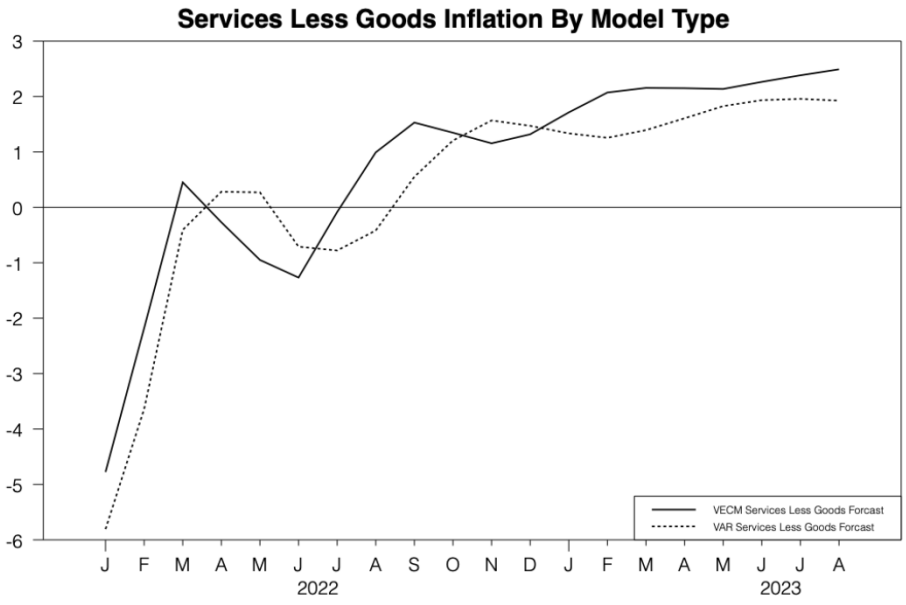


Figure 3.



Both of my models predict around 6% quarterly annualized inflation up through September of 2023. The BVAR is slightly more pessimistic, predicting 6.09% inflation, while the VECM predicts 5.73% inflation. That being said, both models have services inflation surging past goods inflation to reestablish the historical equilibrium. Figure 4 depicts the gap between goods and services forecasted by each model. By September the VAR and VECM models predict services inflation to return to 1.94% and 2.5% above goods inflation respectively. This is probably the more accurate forecast, given that I have not included other exogenous variables that might affect the overall trend of the macroeconomy.

Figure 4.



V. Conclusion and Policy Implications

My VECM model shows that there is a strong equilibrium relationship between goods and services. In September of 2023, I predict that services inflation will return to around 2- 3% above goods inflation. The speed of adjustment towards this long-run equilibrium is estimated to be around 30% per quarter for goods and 14% per quarter for services[4]. This makes sense in the context of the literature. In Bryan and Myer (2010)'s analysis of sticky and flexible prices, they found that the majority of flexible prices are goods and sticky prices are predominately services. This is congruent with my finding that goods prices are much more responsive to shocks in the equilibrium relationship. Specifically, my model says that goods inflation corrects at a faster rate than services, or goods prices accelerate back to equilibrium faster. This would make sense as goods prices change more frequently. These results also make sense in broader economic theory. Wages are known to be sticky (especially downward), and wages tend to be a much larger input in services than in goods.

Given that goods inflation is more responsive to an equilibrium shock, the Federal Reserve should be careful about overcorrecting for aggregate inflation. The majority of the

[4]These are percentages, not to be confused with percentage points

contemporary inflationary spike can be attributed to goods (Figure 1) and thus is likely to self-correct. That being said, even though services did not inflate as much as goods, they still make up a much larger share of consumer expenditures (72.6%). Thus fruitful future research would replicate the work of Bauer et al (2004), and find the precise contributions (factoring in both expenditure share and change in prices) to inflation in the post-COVID economy.

My research also predicts quarterly annualized inflation to settle at 6% in September of 2023. Although my model seems to be a good predictor of the gap between goods and services and the speed of adjustment, it might not be the best forecaster of aggregate inflation. My model potentially lacks the appropriate exogenous variables to fully explain overall trends in inflation. Variables such as interest rates, unemployment, inflation expectations, GDP, and net exports are all directly related to inflation and are not included in my analysis. Future research could incorporate these deterministic variables to achieve a better overall forecast of inflation.

These results also provide further evidence for sticky services prices and support methods of estimating inflation models with goods and services separately. Since it appears that services inflation reacts slower, we can expect it to be better explained by long-run inflation expectations. Furthermore, the more volatile goods series should be estimated as a function of the global economy and short-run inflation expectations. My model predictions warn against over-correction for inflation, as record high goods inflation is set to lower towards its equilibrium relationship with services. The level at which these two series settle, however, is arguably out of the scope of my analysis.

VI. Appendix

Test for Stationary and Cointegration

Goods Inflation ADF	Services Inflation ADF
Dickey-Fuller Unit Root Test, Series X *Regression Run From 1996:02 to 2009:04* *Observations 160* *With intercept* *With 12 lags chosen from 12 by AIC* *Null is unit root. Reject in left tail.* *Sig Level Crit Value* *1%(**) -3.47214* *5%(*) -2.87954* *10% -2.57626* *T-Statistic -2.26066*	*Dickey-Fuller Unit Root Test, Series X* *Regression Run From 1996:01 to 2009:04* *Observations 161* *With intercept* *With 11 lags chosen from 12 by AIC* *Null is unit root. Reject in left tail.* *Sig Level Crit Value* *1%(**) -3.47189* *5%(*) -2.87943* *10% -2.57620* *T-Statistic -2.38781*

Goods and Services Engle-Granger Cointegration Test
Null is no cointegration (residual has unit root) *Regression Run From 1995:03 to 2009:04* *Observations 171* *Using fixed lags 1* *Constant in cointegrating vector* *Critical Values from MacKinnon for 2 Variables* *Test Statistic -5.07686*** *1%(**) -3.96273* *5%(*) -3.37290* *10% -3.07019*

BVAR Regression Output:

Summary of the Prior...
Tightness Parameter 0.100000
Harmonic Lag Decay with Parameter 1.000000
Standard Deviations as Fraction of Tightness and Prior Means
Listed Under the Dependent Variable

	CORECPIGOODSQGA	CORECPISERVICESQ
CORECPIGOODSQGA	1.0	0.5
CORECPISERVICESQ	0.5	1.0
Mean	1.0	1.0

VAR/System - Estimation by Mixed Estimation
Monthly Data From 1995:01 To 2007:04
Usable Observations 148

Dependent Variable CORECPIGOODSQGA

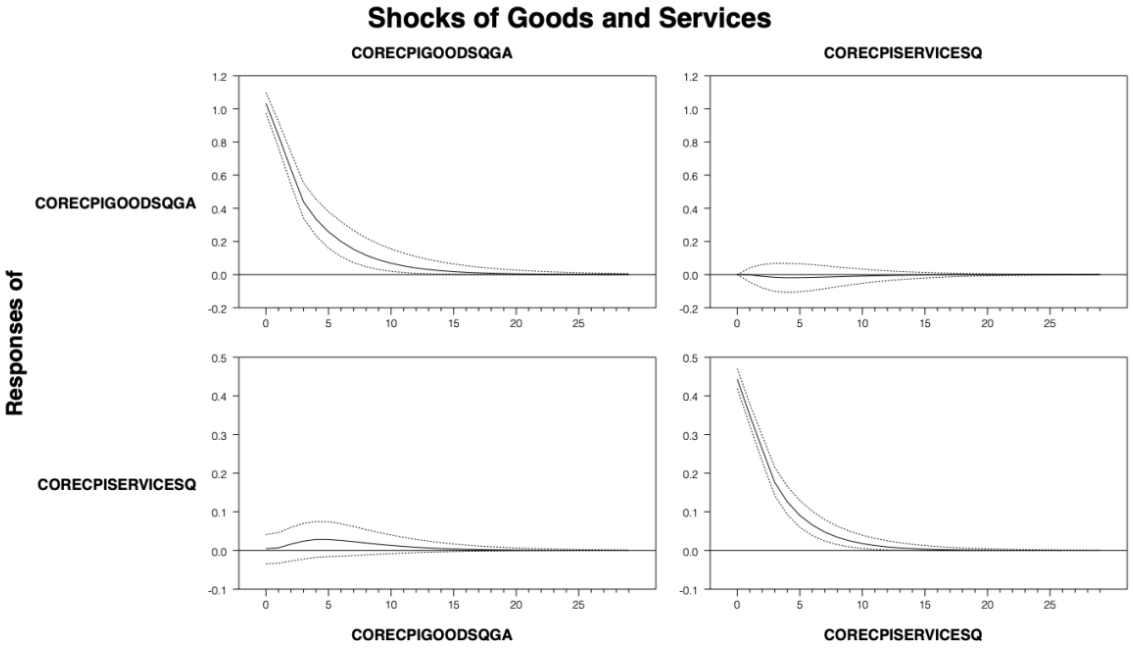
Mean of Dependent Variable	0.1315281426
Std Error of Dependent Variable	1.4748637306
Standard Error of Estimate	1.0006103299
Sum of Squared Residuals	147.17949176
Durbin-Watson Statistic	2.0379

Variable	Coeff	Std Error	T-Stat	Signif
1. CORECPIGOODSQGA{1}	0.813053857	0.056759447	14.32456	0.00000000
2. CORECPIGOODSQGA{2}	-0.047179829	0.045505785	-1.03679	0.30153738
3. CORECPIGOODSQGA{3}	-0.034823829	0.032925972	-1.05764	0.29195449
4. CORECPIGOODSQGA{4}	0.034722743	0.025584926	1.35716	0.17681169
5. CORECPISERVICESQ{1}	-0.003665466	0.095193133	-0.03851	0.96933684
6. CORECPISERVICESQ{2}	-0.016974282	0.058919860	-0.28809	0.77368286
7. CORECPISERVICESQ{3}	-0.003952500	0.040729006	-0.09704	0.92282374
8. CORECPISERVICESQ{4}	-0.000035803	0.030982854	-0.00116	0.99907955
9. Constant	0.105057260	0.352293326	0.29821	0.76596427

Dependent Variable CORECPISERVICESQ
Mean of Dependent Variable 3.1700717398
Std Error of Dependent Variable 0.6094231426
Standard Error of Estimate 0.4302814402
Sum of Squared Residuals 27.215891319
Durbin-Watson Statistic 2.0986

Variable	Coeff	Std Error	T-Stat	Signif
1. CORECPIGOODSQGA{1}	0.003129858	0.017539184	0.17845	0.85861570
2. CORECPIGOODSQGA{2}	0.008511549	0.011072860	0.76869	0.44331316
3. CORECPIGOODSQGA{3}	0.002099271	0.007674702	0.27353	0.78482882
4. CORECPIGOODSQGA{4}	0.001666280	0.005845102	0.28507	0.77598963
5. CORECPISERVICESQ{1}	0.790068715	0.057171356	13.81931	0.00000000
6. CORECPISERVICESQ{2}	-0.033907521	0.044836754	-0.75624	0.45071321
7. CORECPISERVICESQ{3}	-0.042802386	0.032407220	-1.32077	0.18863154
8. CORECPISERVICESQ{4}	0.024573859	0.025151254	0.97704	0.33015297
9. Constant	0.829122994	0.193906833	4.27588	0.00003410

BVAR Impulse Responses:



VECM Regression Output:

VAR/System - Estimation by Cointegrated Least Squares
Monthly Data From 1995:01 To 2007:04
Usable Observations 148

Dependent Variable CORECPIGOODSQGA
Mean of Dependent Variable -0.004716136
Std Error of Dependent Variable 1.096176810
Standard Error of Estimate 0.916135403
Sum of Squared Residuals 117.50257074
Durbin-Watson Statistic 1.9822

Variable	Coeff	Std Error	T-Stat	Signif
1. D_CORECPIGOODSQGA{1}	-0.013232148	0.077777820	-0.17013	0.86515545
2. D_CORECPIGOODSQGA{2}	0.001490930	0.078107575	0.01909	0.98479796
3. D_CORECPIGOODSQGA{3}	-0.492478320	0.076678523	-6.42264	0.00000000
4. D_CORECPISERVICESQ{1}	0.142505363	0.164404903	0.86680	0.38753746
5. D_CORECPISERVICESQ{2}	-0.273245125	0.162455882	-1.68197	0.09480484
6. D_CORECPISERVICESQ{3}	-0.198984449	0.161861685	-1.22935	0.22100323
7. Constant	-0.460555150	0.217535382	-2.11715	0.03601530
8. EC1{1}	-0.294802219	0.134847905	-2.18618	0.03046394

Dependent Variable CORECPISERVICESQ
Mean of Dependent Variable 0.0008738475
Std Error of Dependent Variable 0.4753167445
Standard Error of Estimate 0.4022190260
Sum of Squared Residuals 22.649220278
Durbin-Watson Statistic 1.9804

Variable	Coeff	Std Error	T-Stat	Signif
1. D_CORECPIGOODSQGA{1}	-0.097873390	0.034147484	-2.86620	0.00479610
2. D_CORECPIGOODSQGA{2}	0.011285676	0.034292259	0.32910	0.74256985
3. D_CORECPIGOODSQGA{3}	-0.031769284	0.033664850	-0.94369	0.34695226
4. D_CORECPISERVICESQ{1}	-0.057730869	0.072180138	-0.79982	0.42517211
5. D_CORECPISERVICESQ{2}	-0.011391963	0.071324442	-0.15972	0.87333159
6. D_CORECPISERVICESQ{3}	-0.481511692	0.071063567	-6.77579	0.00000000
7. Constant	0.214164600	0.095506482	2.24241	0.02650697
8. EC1{1}	0.141976601	0.059203468	2.39811	0.01779783

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Joe Biden's Infrastructure Bill

Quang "Sebastian" Pham

I. Introduction

Over the past two years, there have been many major events, namely the COVID-19 pandemic, that have changed the global economy drastically. Covid was so contagious that within only about three months, the World Health Organization (WHO) declared the disease a global pandemic, forcing most governments around the world to shut down any economic activity. As a consequence, In March 2019, panic and uncertainty led to a stock market crash that included the three worst point drops in U.S. history.[5] The pandemic clearly put the US in another recession, following the Great Recession of 2008. Regardless, Congress and the Federal Reserve Board stepped in, cutting interest rates to near zero and launched a $2.3 trillion fiscal rescue package, providing life support to markets, businesses, households and local governments. This is one of the major government spendings that prevented the recession from getting worse and prepared for an economic rebound. Fast forward to November 2021, president Biden recently passed a $1.2 trillion bipartisan infrastructure bill as an effort to "boost the economy" for years to come.[6] As promising as it seems, how does Biden's Infrastructure Bill have an impact on the bond market?

To answer the question, in this paper, I simulate two big major computational models to figure out how the infrastructure bill influences interest rates, and consequently, how it impacts bond prices. The model simulation gives two different results: one before the bill and one after. With these two results, I am able to use them to compare and analyze the effect of the bill on bond prices.

To begin with, I build an IS curve by picking an interest rate and aggregate demand from before the bill was passed. These two values, and any value before the bill is passed, are referred to as 'current' values. Next, since government expenditure does not influence the LM curve, I pick a fixed LM curve to build the IS-LM model with a current equilibrium interest rate and

[5] Frazier, "The Coronavirus Crash Of 2020, And The Investing Lesson It Taught Us."
[6] Long, "Analysis | Biden's Infrastructure Bill Will Bring Jobs. He Wants the Safety Net Bill to Reduce Inequities."

equilibrium GDP. Given the increase in government spending, the IS curve shifts to the right, resulting in a new equilibrium interest rate and a new equilibrium GDP. Thus, with the first model, I analyze the effect of Biden's bill on GDP and interest rate. With both the current and new interest rates from the IS-LM model, I can use them to plug into the Bond Price model to compare two bond prices before and after the infrastructure bill. In order to effectively do so, I also need to pick out a fixed face value and fixed coupon rate. With the given assumptions and calculations, I can calculate and analyze the change in bond yields. Additionally, I can also use the Zero-Coupon Bond Price model, eliminating any coupon payments. Thus, with the two computational models mentioned above, this paper analyzes the effect of Biden's recent infrastructure bill on the bond market.

On top of that, government spending is only a component of aggregate demand, which also consists of consumer spending, investment export, and net export. Thus, in an alternative scenario, we can assume one where consumer spending decreases, exceeding the net increase in government spending, which subsequently shifts the IS curve to the left. In this case, equilibrium interest rate and equilibrium GDP both decrease, resulting in a whole different scenario with a bond price shifting towards the opposite direction, compared to the scenario described priorly.

By analyzing the effect of Biden's recent infrastructure bill on the bond market, I explore the interactions between the IS-LM model and the Bond Price model. Most importantly, the simulation helps me visualize and analyze the effect of government spending on bond price. All things considered, I hope to see if the infrastructure bill can actually improve the economy, making the US grow even stronger as part of a rebound from the pandemic.

II. Model Description

As mentioned above, I will use two models to describe the effect of Joe Biden's infrastructure bill on the bond market. The first model to use is the IS-LM model, which describes how aggregate markets for real goods and money markets interact to balance the interest rate and total GDP in the macroeconomy.[7] Even though the model takes an abstract and simplistic approach to fiscal policy, it helps understand macroeconomy on a basic level. Moreover, the model also helps visualize how a change in variables such as increased government spending affects interest rate and GDP. First and foremost, to construct the IS curve,

[7] "IS-LM Model."

I modified the aggregate demand curve equation (AD = A - B*Y) by adding all of the IS curve's variables to the intercept (A) of the aggregate demand curve. The equation thereby becomes:

$$i = A + S*(1 - T) + I + G + X - B*Y$$

The IS curve equation has a negative slope (B) and consists of many variables: consumer spending (S), taxes (T), planned investment (I), government spending (G), net export (X), equilibrium interest rate (i), and equilibrium GDP (Y). Within the scope of this paper, I assume that all of those variables hold constant. Thus, the infrastructure bill, which represents an increase in government spending, is an input to be added to the intercept of the IS curve. In my computation, this input is represented as a "Shock" to the economy. The increase in government spending shifts the IS curve to the right on the IS-LM model, which in turn increases interest rate (refer to Appendix Figure 1). The variable Y is the equilibrium GDP which I solve for by setting the IS curve equation equal to that of the LM curve. The y-intercept (i)

In this paper, I assume that Joe Biden increased the government's budget without printing any more money. Therefore, the LM curve stays the same for the computation. Similar to the IS curve equation, I use the aggregate supply equation (AS = E + D*Y) as a base to construct an equation for the LM curve:

$$i = (E - M/P) + D*Y$$

The LM curve has a positive slope (D), and real money supply is subtracted from the intercept (E). Real money supply is calculated by taking nominal money supply (M) divided by consumer price index level (P). The LM curve also has the same variables (i) and (Y) as the IS curve. The right shift of the IS curve results in a new equilibrium with a higher equilibrium GDP and a higher interest rate. This new equilibrium makes sense because assuming there is no change in the LM market, so every point on the LM curve represents an equilibrium. Next, now that I have both the IS and LM equations, I can solve for Y by using the function 'fsolve' in Python. Lastly, I use the result of Y, now Y_star, to plug into the LM equation to figure out the equilibrium interest rate (i_star).

The IS-LM model is the foundation to my Bond Price model because once I have the interest rate (i_start), I will use it as an input to plug into my Bond Price model. As I mentioned above, the main goal for this paper is to evaluate how Biden's infrastructure bill impacts the bond market. In other words, to serve my goal, I analyze how the Shock (an increase in

government spending) affects interest rates, which directly influences bond prices. By using Shock, or increase in government spending, as an input, I can analyze the change in the equilibrium interest rate and how that change impacts bond price. Thus, my second model for this paper is the coupon bond valuation model:

$$Price = FV/(1+i)^n + C/(1+i)^1 + C/(1+i)^2 + C/(1+i)^3 + ... + C/(1+i)^n$$

Using interest rates (i_start) as input and using face value (FV), coupon payments (C), and number of periods (n) as variables, I can calculate the bond price, or output of this model, which equals the present value of the face value plus the present value of all coupon payments in the Coupon Bond Price model. The reason why I choose the Coupon Bond Price model is that it allows me to analyze how interest rate can have an influence on the present values of bond price.[8]Within the scope of this paper, I leave other variables (FV, C, n) constant. In this paper, I want to focus on my bond price as my major output. The parameters for both of the models are listed and defined in Table 1.

Table 1. Model Parameters

Parameter	Descriptions	Value
S	Consumer spending (in Trillions $)	10
T	Tax (in %)	0.3
I	Planned investment (in Trillions $)	10
G	Government Spending before the bill (in Trillions $)	3
X	Net exports (assuming that export = import, so they even out)	0
M	Nominal money supply (in Trillion $)	4
P	Consumer Price Index Level	200
A	Intercept of the IS curve	10
B	Slope of the IS curve	10

[8] Hayes, “Bond Valuation.”

E	Intercept of the LM curve	1
D	Slope of the LM curve	1
FV	Face value of bond, the price that the issuer pays at maturity (in $)	1000
c	Annual coupon rate (in %). Annual coupon payments (C) is the product of coupon rate and face value, thus equals $50	0.05
n	Number of periods to maturity (in years)	10

Having everything set up, I simulate the IS-LM model for a total of 22 times in Python, using Shock as my input (discussed further in the 'results' section). Using the 'fsolve' function in Python, I am able to calculate an equilibrium GDP, which I would use to plug in the LM equation (i = E - M/P + D*Y) to calculate the equilibrium interest rate (i_star). For the second input, this equilibrium input will be used as an input to plug in the Bond Price model. All of these inputs are reflected in Table 2.

Table 2. Model Inputs

Input	Description	Used for
Shock	Change in government spending (infrastructure bill)	IS-LM model
i_star	Interest rate as a result of the IS-LM computation to be plugged into the Bond Price model	Bond Price model

I simulate the Bond Price model for a total of 4 times in Python using the resulting interest rate (i_star) as my input, and my computations give 4 different bond prices (discussed further in the 'results' section). In this paper, I want to evaluate the bond market within a period of 10 years; therefore, using the coupon Bond Price model is better than the Zero-coupon Bond one because Zero-coupon Bond is more volatile and is more suitable for short-term projection.[9] Thus, using a coupon bond model would capture a more holistic picture of the whole bond

[9] Langager, "What Is the Difference between a Zero-Coupon Bond and a Regular Bond?"

market. Referring to Table 3, I comprise a list of all the outputs for both models. The output from the IS-LM model is used as an input for the coupon bond pricing model.

Table 3. Model Outputs

Output	Description	Result of
i_star	New equilibrium as a result of change in government spending	IS-LM computation
Price	Bond price before any increase in government spending	Bond Price computation

By comparing these two numbers, I can see how two different interest rates affect bond prices given the same face value, same coupon rate, and same years to maturity. Moreover, by using the IS-LM model, I am able to interpret the interconnection between the two models as I analyze how the change in government spending influences interest rate, which is an integral part of the coupon bond pricing model. Having all these elements, I am able to relate my results to the research question of how Biden's infrastructure impacts the bond market. As I explained earlier, government spending directly influences interest rates which directly influence bond price.

III. Results

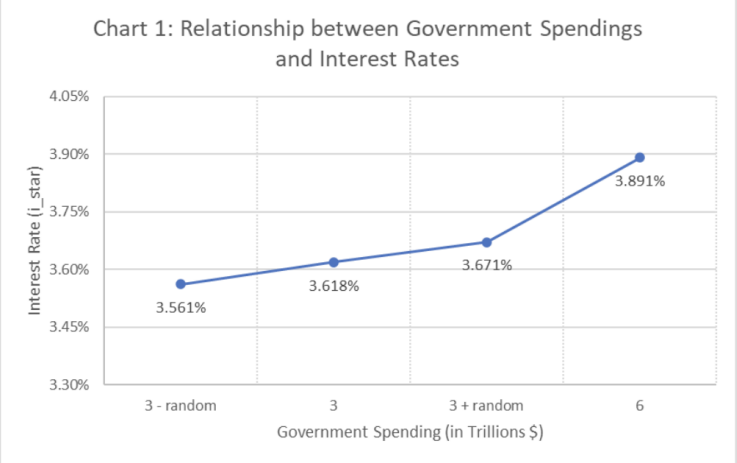
I simulate the IS-LM model for a total of 22 times: 1 time for Shock equals 0 (total government spending before the bill), 1 time for Shock equals 6 (adding a $3 Trillion infrastructure bill), 10 times for a negative Shock, and 10 times for a positive Shock. Considering the last 20 times, I use a random number for Shock, so I run the codes 10 times for each positive and negative Shock to see the variety of the 'random.random()' function. Considering the positive Shock, I got results ranging from 3.630% to 3.708%, all of which are higher than my base case of 3.618% of 0 Shock (Appendix Chart 3). With 10 results, I took the average and got 3.671% which I use as one of the outputs for the IS-LM computation (Table 4). Next, to get

another output from the computation, I did the same method with a negative Shock this time. The reason behind a negative Shock is because of an unexpected change in other input such as a decrease in consumer spending that outclasses the increase in government spending. The 10 test runs for the negative Shock also result in 10 different results, ranging from 3.534% to 3.601%, all of which are lower than my base case of 3.618% of 0 Shock (Appendix Chart 4). The average of these results is 3.561%, which will be used as another output (Table 4).

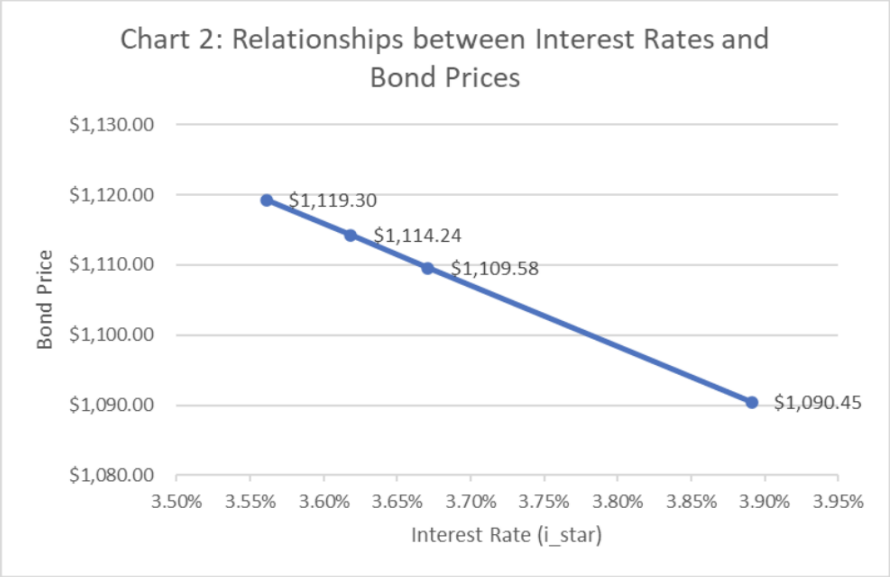
Table 4. Government Spendings (with associated Shock inputs) & Interest Rates

Input	Total Government Spending	Interest Rate
Shock = (-) random	3 - random	3.561%
Shock = 0	3	3.618%
Shock = (+) random	3 + random	3.671%
Shock = 3	6	3.891%

In Chart 1, I represent the relationship between multiple government spendings and interest rates. The result of 3 or 6 is taken directly from the computation, but the results or the other 2 government spendings are the averages of both a negative and positive Shocks. Of these 4 results, we can see a positive relationship between government spending and interest rates.



Next, I plug all of the interest rates from Table 4 into the coupon Bond Price model, which results in 4 different bond prices (Chart 2).



The different interest rates result in different bond prices. As interest rates increase, bond prices decrease. Notably, my base case of 3.618% interest rate leads to a bond price of $1,114.24. With Biden's infrastructure bill (interest rate equals 3.891%), I get a bond price of $1,090.45. To serve the goal of this paper, I comprise Table 5, which shows the interrelationship between government spending and bond prices, with interest rates as the connection. From the table, I can see that the higher the government spending, the lower bond prices are.

Table 5: Bond Prices with associated Government Spendings & Interest Rates

Input	Total Government Spending	Interest Rate	Bond Price
Shock = (-) random	3 - random	3.561%	$1,119.30
Shock = 0	3	3.618%	$1,114.24
Shock = (+) random	3 + random	3.671%	$1,109.58
Shock = 3	6	3.891%	$1,090.45

From the results in Table 5, I can make a conclusion that the increase in government spending results in an increase in interest rates, which consequently decreases bond prices. The negative Shock is considered as the unlikely scenario where an increase in government spending results in a lower GDP, decreasing interest rates. On top of that, the negative Shock helps me better identify the relationships between government spending and bond price as the Shock acts as an extra variable input. All things considered, an increase in government spending, or Biden's infrastructure bill, leads to a decrease in the bond prices due to higher interest rates, but what does this mean to the economy and the bond market?

As I read further into Biden's infrastructure bill, the funding will be gradually spent over the next five years, which implies that the impact of the bill on the economy is not immediate after its passing in November 2021. As Lobosco suggests in a CNN article, "the investments are likely to have more of a long-term impact on job creation than an immediate boom" since we are not in a recession anymore.[10] The article also implies that even though infrastructure spending can take a while, its benefits are long-lasting. This brings me to an assumption that Biden's infrastructure bill will have a positive impact on the economy as we have recently stepped out of a recession not long ago. As the economy grows, GDP also increases. Analyzing the IS-LM model, GDP and interest rate will both increase since they are tied to both markets. Furthermore, since bond prices are closely tied to the economy, the increase in interest rates will thereby decrease bond prices over time. As bonds are sold for lower prices, bond yields rise, which indicates that there is a decline in demand for bonds that pay lower fixed interest rates, notably zero-coupon bonds.[11] This phenomenon is mainly due to the higher risk associated with rising interest rates that cause a great decrease in bond prices.[12] When interest rates rise and new bonds with higher yields than older securities are issued in the market, investors tend to purchase the new bond issues to take advantage of the higher yields.[13]

[10] Lobosco, "Here's How Long It May Take Biden's Infrastructure Package to Jolt the Economy."
[11] Lioudis, "The Inverse Relationship Between Interest Rates and Bond Prices."
[12] Gallant, "Interest Rate Risk Between Long-Term and Short-Term Bonds."
[13] Ibid.

IV. Conclusion

All in all, this paper analyzes how the change in government spending can have an impact on bond prices, and effectively the bond market. The last paragraph of the Results section analyzes how Biden's infrastructure bill might affect interest rates as well as how bond investors' behavior might change if there is a rise in interest rate, which is likely the outcome in our economy in the next few years. I learned that it will take time before actual effects or benefits of the bill accrue, but by using both the IS-LM and the Bond Price models, I am able to predict how the interest rates and bond price will most likely behave in the future. Therefore, this paper successfully answers the question addressed in the Introduction section: how does Biden's Infrastructure Bill have an impact on the bond market?

V. Appendix

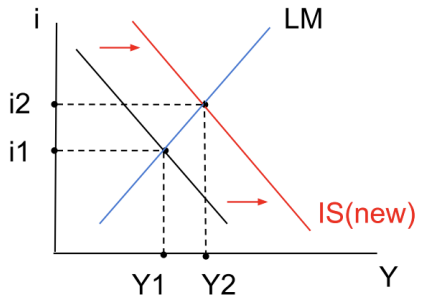
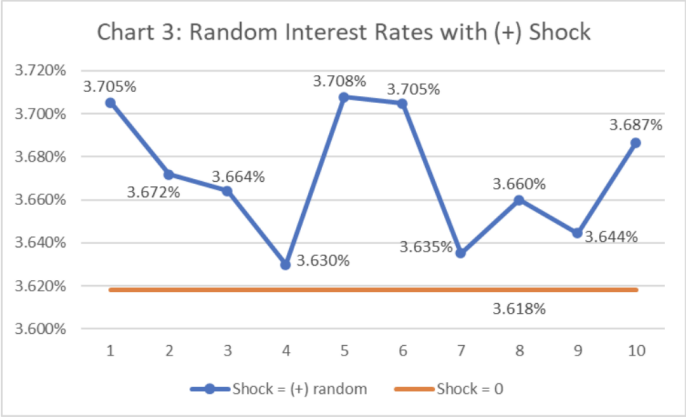
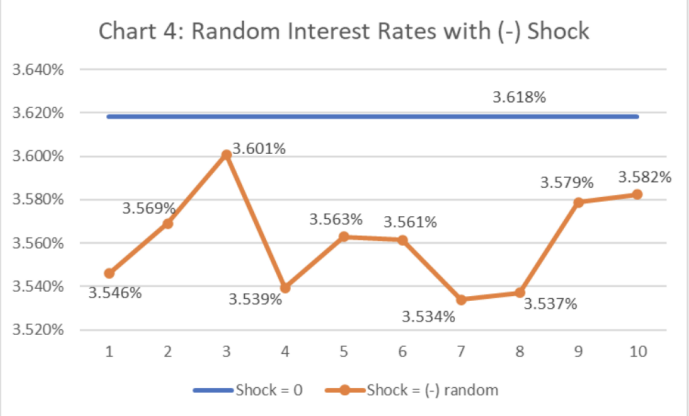


Figure 1





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Effects of Inflation Expectations on CPI Before and After the Great Recession: Econometric analysis of inflation's impulse response to consumer inflation expectations

Marco Bibriezca

I. Introduction

Following a White House event, Fox News journalist Peter Doocy found himself wondering whether high inflation could present a challenge to democrats in the 2022 midterms—President Biden, *allegedly* unaware of the live microphone in the room, sarcastically replied "it's a great asset, more inflation."[14] (Reuters 2022). To Doocy's defense, economists have struggled for decades to craft a comprehensible theory on inflation, the factors that drive it, and its effects on the overall economy. Seasoned academics with sophisticated forecasting models at their disposal can only get us so far. While those sitting behind a screen can leverage the power of data to generate predictions, the regular consumer has continued to exhibit growing uncertainty. Inflation uncertainty is believed to have risen drastically following the Great Recession likely as a result of expansive monetary policy (Drakos and Kouretas 2015). This is revealed by consumers' inflation expectations over the last two decades, which continue to diverge from realized inflation.

Through the end of the 20th century, American households' inflation expectations (measured by the Michigan Survey of Consumers) closely matched realized inflation as reported by asset prices as well as the forecasts of Professional Forecasters (PF) (*See Figures 1 and 2)*. This trend held for well over two decades until shortly before the Great Recession. Around 2005, American households' inflationary expectations began to deviate from those of Professional Forecasters and markedly departed from recorded inflation as reported by the Cleveland Federal Reserve Board (*See Figures 2 and 4)*. By 2005, consumer inflationary expectations diverged from actual values by over 100 basis points, reaching a historic high shortly before the onset of the Great recession and further spiking sharply between 2009 and 2011. Granger causality tests indicate American's inflation expectations *had* predictive content for inflation data from 1960

[14] Subsequent verbal slip excluded.

through 2005 (Canova and Gambetti 2008).[15] What happened in 2005? What made Americans' expectations of economic outlook so misguided?

Using conventional Bayesian VAR frameworks, error decomposition, Granger causality tests, and impulse response functions (IRF) this paper explores the extent to which monetary and fiscal policy responses during the Great Recession, altered the dynamics by which inflation responds to household expectations, which would be indicative of monetary policy shifting away from considering inflation expectations in the same manner it did pre-Great Recession. In order to understand the processes by which households form expectations and how these come to play a role in actual inflation, a comprehensive review on the theory of inflation is necessary—to this issue I now turn.

A. Inflation and Expectation, Generally

While debate exists as to the exact causal mechanism, monetary policy models consider inflation expectations to have *some* effect on overall inflation (Clarida et al. 1999; Smets 2003; Woodford 2003; Levin and Moessner 2005; Moessner 2021). Whether household's inflation expectations *actually* matter is somewhat up for debate; with some scholars suggesting consumer expectations have no significant effect on overall inflation (Rudd 2021), and an army of macroeconomists pushing against that claim. (Galí and Gertler 1999; Brissimis and Magginas 2008; Coibion et al. 2018; Coibion and Gorodnichenko 2015b; Kohlscheen and Moessner 2021; Moessner 2021). The latter arguments are grounded in macroeconomic theory. The perceived importance of measuring inflation expectations from this point of view has to do with the role played in driving monetary policy—reflected in sticky price models and the New Keynesian Phillips Curve (Woodford 2003, Gali and Gertler 1999; Bernardo et. al., 2021). To that end, inflation expectations and real inflation are thought to be correlated through a price expectations mechanism that incentivizes workers to enter into wage bargains over anticipated rises in prices (Friedman 1968). Consumer inflation expectations in the long vs. short run are thought to affect inflation differently. Those who protest models that include household's inflation expectations cite empirical evidence pointing to the fact that long run expectations are the only metric of expectations that is even slightly relevant to inflationary dynamics (Rudd 2021).

[15] Using VAR models, the authors examined the predictive capability of 1-year inflation expectations for realized inflation. Granger causality tests seemed to indicate expectation consistently had predictive content for inflation through 2005.

Whatever their effect, understanding how ordinary economic agents come to form these subjective inflation expectations is crucial given households are believed to take into account the expected rate of inflation when making economic decisions (i.e., whether to buy a car now or next year) (Bullard 2016). Additionally, lacking a systematic way to track how firms come to form inflation expectations, firms' inflation expectations are believed to be proxied by consumer expectations (Coibion and Gorodnichenko 2013). In fact, recent studies have found U.S. firms to be equally uninformed when it comes to inflation and monetary policy, thus the notion that firm's expectations follow those of consumers holds (Bernardo et. al. 2021).

Forecasting American household's inflation expectations and their effect (again, if any) on the economy is a complicated matter. These economic agents tend to (a) rely on assumptions that deviate from macroeconomic theory when forming expectations and (b) place significant weight on subjective experiences and beliefs (Weber 2022). Over the years, the literature continues to highlight the role played by heterogenous personal experiences and attributes in shaping inflation expectations. Some of these include, but not limited to; exposure to prices of gas; disproportionate expenditure shares on goods purchased; frequency of purchase; exposure to grocery prices; gender; educational attainment; income; the media; views about the nature of an economic shock; experiences of close circle individuals; and consumers ability to recall previous prices (Weber et al. 2022; Weber et al. 2021; D'Acunto et al. 2021a,c,e; Cavallo et al. 2017). Nonetheless, the literature agrees, consumer's expectations are generally biased upwards and "very sensitive to the prices most frequently experienced by households" (Weber et al. 2022). This upward bias is true for both Professional Forecasters and household expectations, but remarkably higher for households (See Figure 1). When contrasting households' bias to that of PF, the literature suggests explanations to be grounded in rational inattention models, sticky information, and asymmetric forecasting loss functions (Drakos, Konstantinou, and Thoma 2020).

This upward bias as a result of frequent price exposure is demonstrated in the role played by oil prices as a predictor of household's inflation expectations. This relationship, Coibion and Gorodnichenko (2013) assert, is likely to arise from the fact that the average household, and not PF, interacts with oil prices much more frequently—finding models including oil prices to account for the differences in bias of household inflation forecasts from those of professionals.

To the extent that consumer expectations will be a deterministic factor of realized inflation, these expectations will come to be formed based upon the prices for goods and services experienced.

Having outlined a general understanding of how consumer's form inflation expectations and how they tend to compare to those of PF and realized inflation, the following section provides a review of the literature seeking to explain how economic shocks (such as the Great Recession) can affect people's ability to form accurate inflation expectations as well as how monetary and fiscal policy can affect the response of inflation to prices and other factors believed to drive it. In order to understand the work done by others in this field and the methods by which they investigate their hypotheses, I provide a review of methods for analysis for understanding these effects. Those steps are outlined in Section III followed by a description of the data used. Section IV presents the results of my investigation with Section V discussing the observed outcomes and Section VI concluding.

II. Literature Review

Inflation expectations and inflation itself are highly sensitive to economic shocks (Orphanides and Williams 2005) and there's evidence to suggest the Great Recession unequivocally changed people's perception of the state of the economy and by extension their response to economic shocks. Using a Vector Autoregressive Model (VAR) regressing long-run inflation expectations on a constant, a set of macroeconomic news variables, and a set of control variables, Gelati and colleagues (2018) found evidence suggesting American's long-run inflation expectations to be less perfectly anchored following the Great Recession "and probably earlier." This de-anchoring of expectations was attributed to an increased sensitivity to economic news.

Literature suggests this sensitivity was not as marked prior to the economic crisis of 2008. In a study investigating the role of short and long run expectations prior to the Great Recession (1981:Q3 to 2008:Q2) Clark and Davig (2008) analyzed the impulse responses of CPI, short-term expectations, and long-term expectations. They found that shocks to inflation correlated to a temporary rise in short-term expectations and a small rise in long-term expectations; shocks to short-term expectations produced small increases in long-term expectations and inflation; and shocks to long-term expectations were found to increase short-term expectations and realized inflation (Summarized in Figure 5).

The use of conventional VAR frameworks, structural Bayesian VAR models, and impulse response functions to investigate the role of expectations and inflation is standard in the literature (Istrefi and Piloiu 2014; Herrington and Mehra 2008). Given a stable relationship between these measures, VAR models incorporating macroeconomic variables and short run expectations were employed by Leduc and colleagues (2007); models including short and long term inflation expectations as well as disaggregate measures of CPI are consistent with those used by Clark and Davig (2008). The potential for improved and efficient inflation forecasting models through the disaggregation of its components is now well established (Peach et. al. 2004; Clark 2004; Peach et. al. 2013; Tallman & Zaman 2017). By modeling goods and services separately, Tallman & Zaman (2017) isolated a statistical relationship between services inflation and the unemployment rate. Additionally, Peach et al. (2013) found long-run inflation expectations to be a driver of services inflation, but not goods.

The mechanism by which changes in monetary policy affect inflation appears to be relevant when it comes to understanding the changing impact of expectations on realized inflation. Literature suggests that prior to 1979, shocks to inflation expectations had "permanent effects on both inflation and expectations [themselves]" (Leduc et al. 2007). Since the 1980's however, the response of inflation to expectation shocks seems to have diminished. According to Clark and Davig, these changes in response are consistent with changes to monetary policy. Specifically, prior to 1979 the federal funds rate had a negative relationship with expectation shocks—since 1979, however, "the real rate has risen significantly in response to expectations shocks." (2008). The relationship by which changes in monetary policy affect the degree to which other determinants of economic activity respond to expectations could help explain changes in the response of CPI to inflation expectations.

The varying response of people's expectations to shocks in inflation as they relate to monetary policy tend to be associated with trust. Public trust in central banks is necessary in order to efficiently manage expectations (Christelis 2020). Using survey responses about inflation expectations, Christelis and colleagues found that general trust in central banks induces anchored expectations and lowers uncertainty about future price developments (2020). It is possible that diminished trust in the country's financial institutions brought about by monetary responses during the Great Recession may have diminished people's trust, de-anchoring their expectations and diminishing their ability to form accurate inflation expectations. Lacking results

consistent with this paper's hypothesis, that monetary responses during the Great Recession altered the dynamics by which inflation responds to expectation shocks, trust in financial institutions may help explain the diminishing role of expectations on realized inflation.

III. Data and Methods

Monthly data was used for all variables of interest. Data on inflation for all urban consumers (CPIAUCSL); core inflation (CPILFESL); federal funds rate (FEDFUNDS); and Michigan Survey of Consumers 1-year Inflation Expectations (MICH) were obtained from the Federal Reserve Economic Data (FRED), a database maintained by the Federal Reserve Bank of St. Louis. Data on the Michigan Survey of Consumers 5-year Inflation Expectations were obtained from the University of Michigan's database.

The use of consumer expectations, inflation rates, and federal fund rates as data for predictive VARs is consistent with methods employed by Clark and Davig (2008) and other studies analyzing the impulse responses of inflation. Once read in for analysis, the variables were redefined as follows; inflation as CPI, 1-year expectations as MICH1, 5-year expectations as MICH5, and the federal funds rate as FEDFUNDS. All variables were initially expressed in rates but were differenced in order to achieve series stationarity.

Canova and Gambetti (2008) and Clark and Davig (2008) used VAR models to examine the predictive content of one-year ahead expectations for inflation. Consistently, to model the impulse responses of CPI after changes to consumer expectations, I constructed two restricted Vector Autoregressive (VAR) models; one for the time period designated `Pre-Great Recession` spanning 1997:04 to 2007:04 and another for the time period `Post-Great Recession` which spans 2009:04 to 2019:04. The final lag length for both VAR processes were selected using Sim's Corrected Likelihood Ratio Tests. Autoregressive Unit Root Tests were also employed to test for system stationary. Following Granger (1939), these VAR models were used to test for Granger causality using F-Tests. A varying ordering of variables were considered using causality testing, error decomposition, and F-Tests. Close examination of impulse responses consisted of joint analysis of F-Tests (summarized in Figures 6 and 7), error variance decomposition (Summarized in Figures 8 and 9), and impulse response functions (See Figures 10 and 11).

The benchmark VAR model contains four variables, with five lags of each, in the following order: CPI inflation, short-term expectations, long-term expectations, and the

federal funds rate. The decision to keep the VAR model with the least number of variables as possible was made consistent with and Davig (2008), who indicate VAR models may lose reliability when there are time-varying parameters.

IV. Results

A. Pre-Great Recession

Lag lengths 7, 6, and 5 were considered for the Pre-Great Recession model. The Sim's procedure rejected the VAR(7) model X2(16,116)= 34.09, p-value= 0.005 for the VAR(6) model. Further lag exclusion tests to reduce down to 5 lags yielded insignificant rules X2(16,116)= 20.98, p-value= 0.179. Autoregressive Unit Root Tests on the VAR(6) system yielded $q < 1$ at 0.904 suggesting the system to be stationary as further corroborated by the impulse response functions' eventual return to equilibrium. Granger causality F-Tests revealed causality orderings as follows; $FEDFUNDS \rightarrow CPI \rightarrow MICH1 \rightarrow MICH5$. No feedback was evidenced in these Granger tests (See Figure 6). Error decomposition at 16 steps found FEDFUNDS to explain 7.02% percent of CPI Inflation's standard error; MICH1 to explain 4.40%; and MICH5 to explain 2.06% (See Figure 8), In terms of FEDFUNDS, MICH 1 was the second highest determinant of its standard error at 16 steps, explaining 5.83% and FEDFUNDS explaining 88.95%. No other significant explanatory relationships were observed.

Close examination of impulse responses (See Figure 10) shows this system is stationary. Furthermore, we observe shocks to MICH1 generate modest, long lived responses in CPI Inflation. Additionally, shocks to MICH1 generate the greatest response from FEDFUNDS than any other variable in the system (namely MICH5). Shocks to CPI and FEDFUNDS generate substantially greater and longer lived responses in MICH1 when compared to the responses generated in MICH5.

B. Post Great Recession

Lag lengths 7, 6 and 5 were considered for the Post-Great Recession model. The Sim's procedure rejected the VAR(6) model X2(15,116)= 15.90, p-value= 0.459 in favor of the greater VAR(7) process. Autoregressive Unit Root Tests on the VAR(7) system yielded $q < 1$ at 0.94 suggesting the system to be stationary as further corroborated by the impulse response functions' eventual return to equilibrium. Granger causality F-Tests revealed causality orderings as follows; $MICH1 \rightarrow MICH5$. No feedback was evidenced in these Granger tests (See Figure 7). Error

decomposition at 16 steps found FEDFUNDS to explain 7.48% percent of CPI Inflation's standard error; MICH1 to explain 2.48%; and MICH5 to explain 2.68% (See Figure 9), In terms of FEDFUNDS, CPI Inflation was the second highest determinant of its standard error at 16 steps, explaining 4.34% and FEDFUNDS explaining 91.78%. No other significant explanatory relationships were observed. MICH1 lost its 5.83% error explanation of FEDFUNDS from the Pre-Recession system to below 1% in the Post-Recession system.

Close examination of impulse responses (See Figure 11) shows this system is stationary. Furthermore, we observe shocks to MICH1 generate modest, short lived responses in CPI Inflation. MICH1 lost the effect on the FEDFUNDS response previously observed. Shocks to CPI and FEDFUNDS generate small and short lived responses in MICH1. Alternatively, shocks to FEDFUNDS generate larger and longer lived impulse responses in MICH5.

V. Discussion

Prior to the Great Recessions, the observed causality patterns are consistent with the literature and the expected mechanisms according to macroeconomic principles. The effective federal funds rate moves the savings rate, which in turn affects consumer demand ultimately corresponding to inflation as measured by the CPI. Literature suggests that customer's proximity to prices then affects their future inflation expectations. As such, we observe that changes (or shocks) to CPI affect 1-year forward inflation expectations which transfer to 5-year expectations.

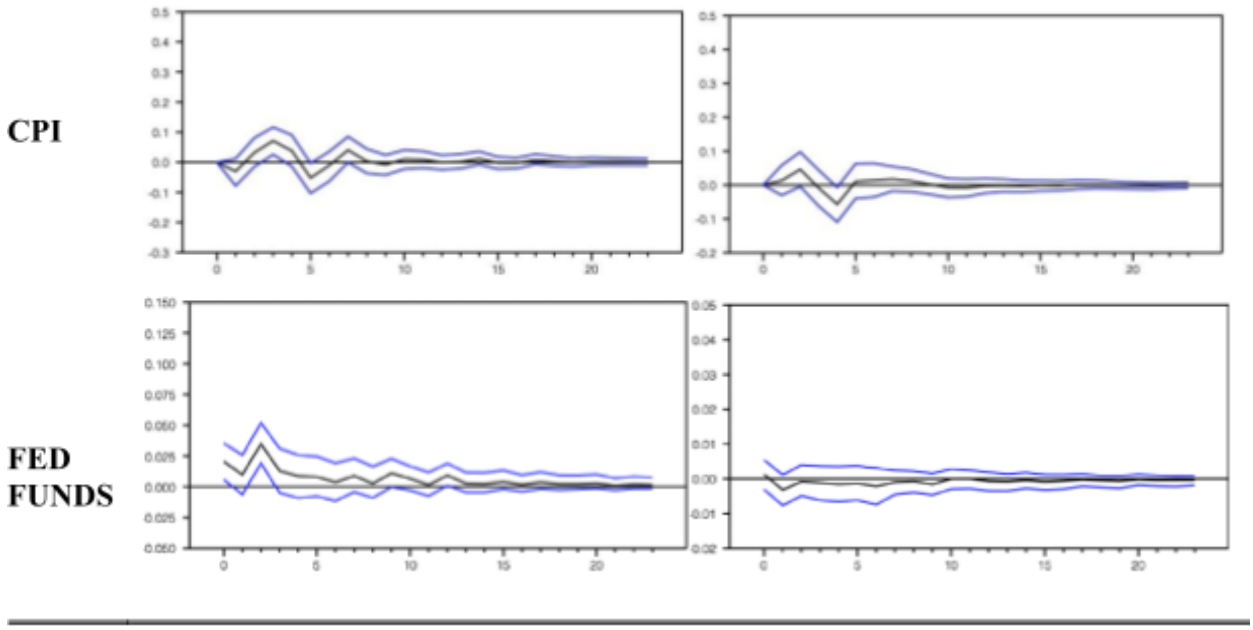
There is reason to expect feedback in this system specifically, long term expectations to affect CPI inflation, however, no such feedback was evidenced in Granger tests. The established Granger causal relationships in this Pre-Recession period were diminished substantially in the Post-Great Recession period, where the effective federal funds rate lost its Granger causality on CPI inflation as well as 1-yr inflation expectations. The one remaining, logically consistent relationship, was that short term expectations influence long-term expectations.

Much similarly, error decomposition explanations by short term expectations on CPI inflation, which were close to insignificant in the Pre-Recession period, lost any explanatory effect over the standard errors observed in the Post-Recession CPI. The explanatory effect of longer-term expectations on CPI inflation increased ever-so-slightly. Furthermore, short-term inflation expectations lost their explanatory effect over the effective federal funds rate.

Close examination of impulse responses confirms the developed intuition from causality tests and error decomposition. Prior to the Recession, changes in people's short-term inflation expectations generated modest but long lived effects in CPI inflation, whereas, after the recession, this impulse response diminished in both magnitude and duration. Likewise, changes in short-term expectations before the Recession generated large and long lived impulse responses in the effective federal funds rate—a response substantially diminished after the crisis (See Table 1).

Table 1

Pre and Post-Recession CPI and FEDFUNDS Responses to MICH1 Shocks



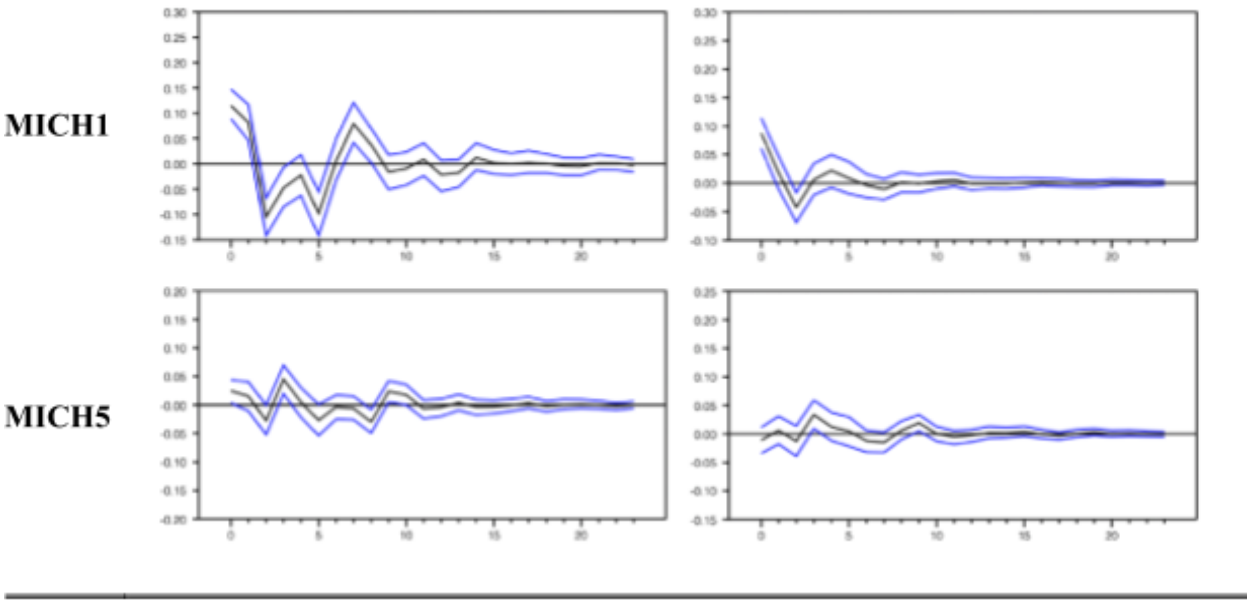
Note: MICH1 denotes short-term (1yr) inflation expectations as measured by the Michigan Survey of Consumers.

The observed trends in impulse responses directly call into question some of the main assumptions underlying the New Keynesian Phillips Curve, under which we expect changes in people's inflation expectations to trigger a wage-bargaining mechanism that leads to an increase in production prices, a rise in prices, and eventually price inflation. Secondly, the Federal

Reserve Board's response to people's short-term expected inflation seems to have drastically diminished following the financial crisis—further investigation into this matter is merited. Alternatively, shocks to CPI inflation generated responses that were large in magnitude and duration for both short and long term expectations in the pre-Recession, a response that significantly diminished post-recession. In fact, short and long term expectations achieve equilibrium much faster than they did pre-Recession (See Table 2).

Table 2

Pre and Post-Recession Expectation Responses to CPI Shocks



Note: MICH1 denotes short-term (1yr) inflation expectations while MICH5 denotes longer term (5yr) inflation expectations as measured by the Michigan Survey of Consumers.

The observed trends above are not as striking as the ones from Table 1. In fact, a diminished response in people's inflation expectations following real inflationary shocks suggest that people's expectations are, in fact, well-anchored, and have generally improved over time. Drakos, Konstantinou, and Thoma (2020) believed explanations to be grounded in rational inattention models—the impulse responses agree. The cost of inattention following the great

economic crisis became much more pronounced, as such, people are likely to have become more attentive to economic events and thus their propensity to vastly change their inflation expectations given a shock was diminished.

VI. Concluding Remarks

This paper sought to investigate changes in responses of inflation to people's inflation expectations before and after the Great Recession by evaluating the extent to which inflation's stochastic impulse response functions to shocks in inflation expectations changed post Great Recession. Results suggest a reduction in the impulse response of CPI inflation to shocks in short term expectations. Furthermore, results suggest the effective federal funds rate became much less responsive to people's inflation expectations following the Great Recession. Alternatively, people's response to economic shocks (as measured by CPI inflation) became much less pronounced, suggesting people's expectations became better anchored post-Recession.

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VI. Appendix

Figure 1.

1-Year-Inflation Forecasting and Realized Inflation

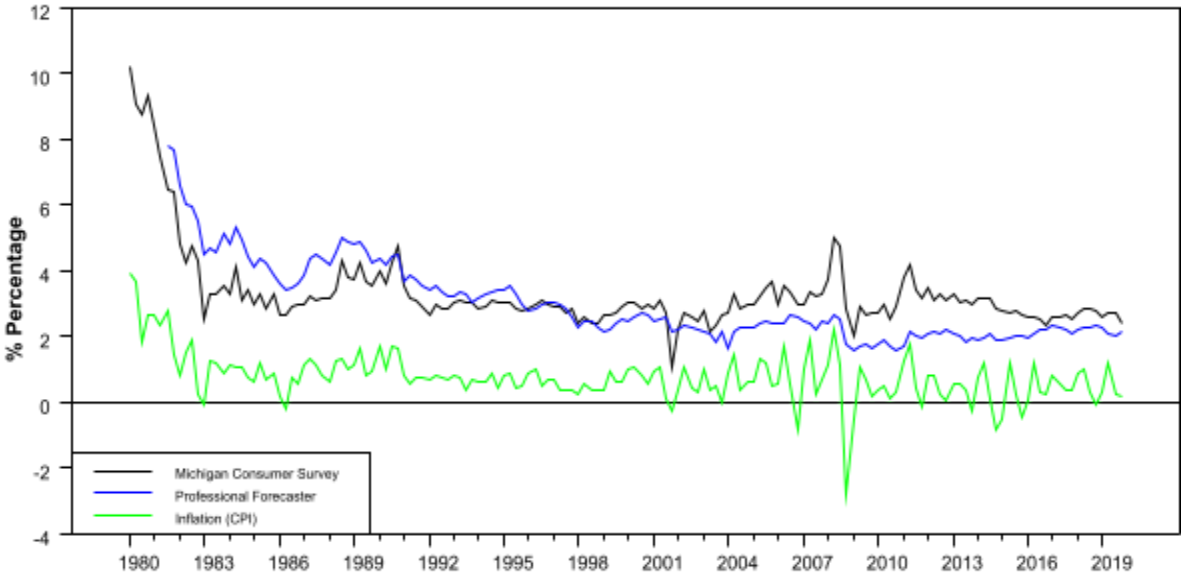


Figure 2.

1-Year Inflation Forecasting

Figure 3.

Difference: Realized Inflation Minus Michigan Consumer Survey

Figure 4.

Difference: Professional Forecast Minus Michigan Consumer Survey

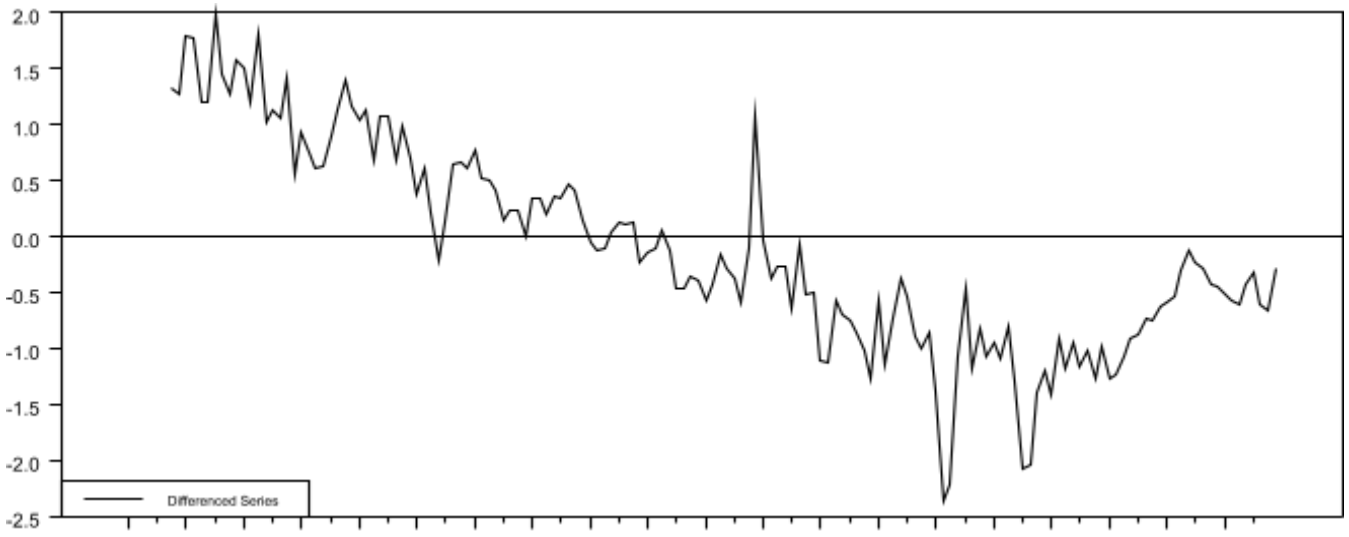


Figure 5.

Decomposition of Variance for Series CPI (Pre-Great Recession)

Step	Std Error	CPI	MICH1	MICH5	FEDFUNDS
1	0.39368833	100	0	0	0
2	0.42090385	95.435	0.427	1.825	2.313
3	0.44775173	93.81	0.795	1.627	3.768
4	0.46940589	92.559	2.452	1.483	3.506
5	0.47145545	91.767	2.895	1.847	3.491
6	0.47787018	89.34	3.753	1.798	5.109
7	0.48008268	88.519	3.768	1.866	5.847
8	0.48242918	88.005	4.354	1.85	5.791
9	0.48323766	87.757	4.347	1.889	6.007
10	0.48579693	87.148	4.342	1.927	6.583
11	0.48608312	87.051	4.361	1.93	6.658
12	0.48638567	86.983	4.382	1.985	6.65
13	0.48703433	86.794	4.371	2.032	6.803
14	0.48782909	86.582	4.357	2.066	6.995
15	0.48808008	86.529	4.403	2.066	7.002
16	0.48820701	86.513	4.401	2.066	7.02

Figure 6.

Decomposition of Variance for Series CPI (Post-Great Recession)

Step	Std Error	CPI	MICH1	MICH5	FEDFUNDS
1	0.37889175	100	0	0	0
2	0.42254198	97.738	0.16	0.395	1.708
3	0.43040049	95.246	1.059	0.435	3.26
4	0.43350696	94.762	1.127	0.43	3.68
5	0.43727695	93.14	2.655	0.485	3.719
6	0.44768431	89.513	2.703	1.9	5.884
7	0.45030336	88.988	2.672	1.882	6.457
8	0.45117902	88.682	2.712	1.96	6.645
9	0.45230776	88.364	2.71	1.987	6.939
10	0.45270795	88.23	2.711	1.99	7.069
11	0.45329665	88.021	2.808	2.006	7.165
12	0.45419412	87.768	2.802	2.017	7.413
13	0.45447409	87.693	2.799	2.015	7.493
14	0.45454265	87.669	2.798	2.02	7.513
15	0.45468554	87.616	2.796	2.019	7.569
16	0.45480686	87.569	2.798	2.02	7.613

Figure 7

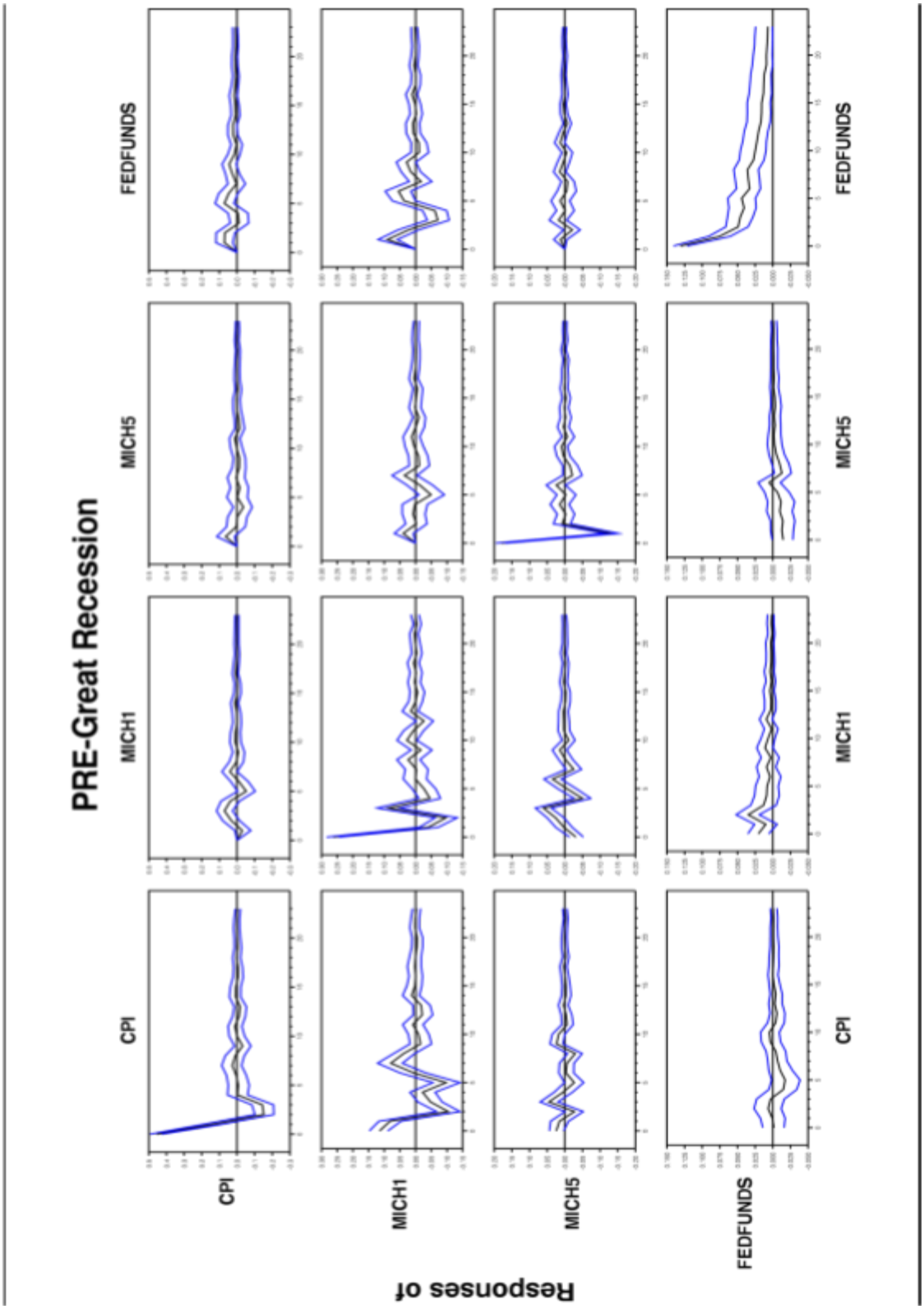
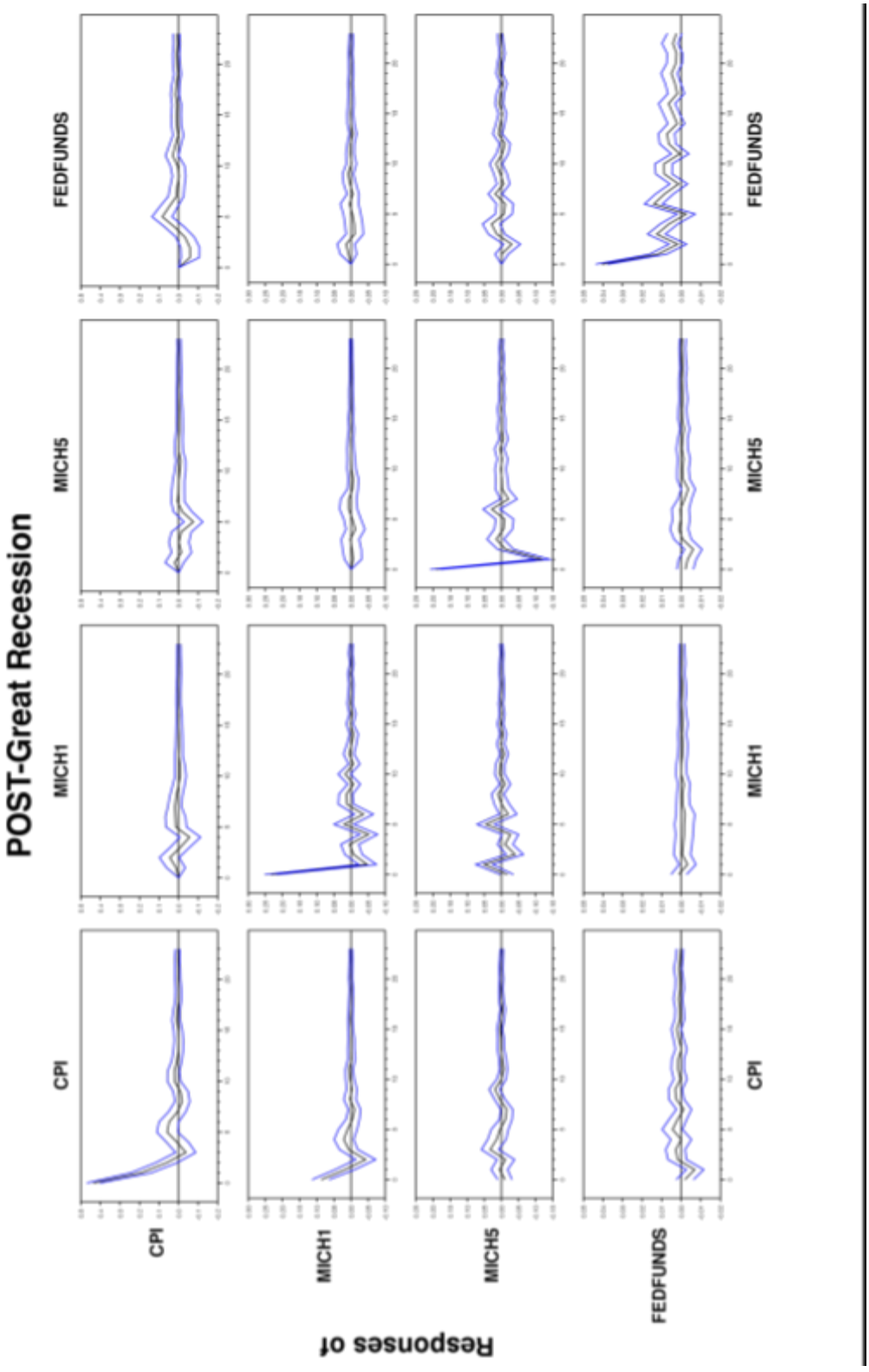


Figure 8


POST-Great Recession
CPI
MICH1
MICH5
FEDFUNDS
Responses of

Reinventing Cross-Border Remittance for Myanmar Migrant Workers

Morkmoongmuang “Meg” Prapatthong

I. Introduction

“Will you accept wire transfer?” is a popular phrase from a Netflix series based on the true story of Anna Delvey. A con artist and a self-proclaimed German heiress claimed to “wire transfer” her trust funds from Germany to spend on private jets in the United States. But not everyone is an heiress like Anna. Ordinary people who live abroad use remittance services like Western Union or Remitly. Unfortunately, these banks fail to provide Myanmar migrant workers the services. The political unrest and genocide in Myanmar immensely impact the financial institutions. Millions of Myanmar migrant workers are left behind and unable to send back money to their loved ones through the conventional methods.

The survival of their families in Myanmar depends on the money from the migrant workers. While they are working their sweats off for less than $10 a day in Thailand, many remittance brokers are taking advantage of migrants’ limited finance literacy, not knowing the ins and outs of the banking system in Thailand. They are overcharging the transfer fee of 12.5 times higher than remitting through a commercial bank. In addition to the absurdly large cut, these brokers also run skeptical business that often includes money laundering and fraud. Despite governmental and institutional banking intervention, Myanmar migrant workers stick with using brokers. But they will no longer be abused and fearful, the proposed blockchain-based remittance platform aims to improve their remitting experience.

With the technological advancement and the introduction of blockchain in the financial sector, a blockchain-based platform for remittance transfer aims to eliminate the unreasonable fees and illegal-related risk that a Myanmar migrant worker goes through using a broker. Throughout this paper, I will analyze the principal-agent models of the remittance platform, with a primary focus on the referral program, a feature to incentivize the workers to invite their friends to join the platform. The examination of variable elasticities supports the success of blockchain-based remittance platforms among the Myanmar migrant workers. With the

overarching framework of public goods and game theory, the platform serves the migrant workers as the future of modern remittances in a borderless world.

II. Literature and Industry Review

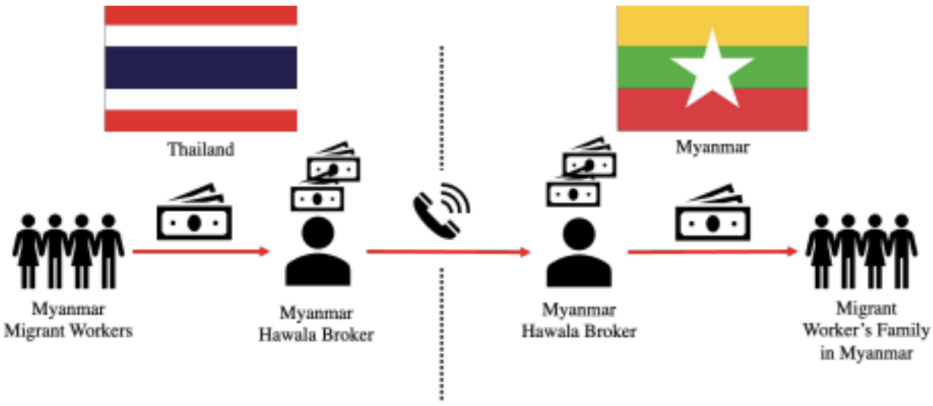
Remittance transfer is one of the largest industries in the world. Over $630 billion of remittance has been sent to low- to middle-income countries in 2022 (World Bank, 2022). People who use informal methods for remittance transfer are believed to send larger than 50% of the recorded flows (Ratha, 2017). For those who choose formal transfer methods, they go to the bank or use an online remittance platform. The methods of remittance transfer can be considered a monopolistic competition market. The main players are the banks; a bank like Western Union is a long-standing example. They offer both in-person services where people bring in cash and an online system for easier accessibility. These online banking systems are very similar to each other. However, each bank may offer different exchange rates or fees; the users may shop around for the best prices. The cost of these banks is that there are many competitors, the newcomers must lower the transfer fees, offer better exchange rates, or provide additional incentives for the people such as points collection for transfer fee reductions. However, these formal methods are not optimal for migrant workers who live under political unrest or developing countries with poor banking systems. Not everyone can afford to open a bank account. The proposed blockchain remittance platform assists these groups of people by not requiring complicated bureaucratic procedures like the formal banking system, while maintaining low fees and a secure environment for fund transfer.

The developers of blockchain prioritize the solution to the trust and security issue in financial transactions. Users enjoy cost-effective, secure and private payments under the technology (Egelund-Müller et al., 2017). The design of blockchain builds “trustless trust” where there are no human counterparts or higher authorities in the process of blockchain (Werbach, 2019). With the cooperation of the distributed ledger as a procedure of remittance, the first blockchain based currency like Bitcoin has been introduced (Rella, 2019). Many startups are researching and adopting the technology to find the financial solution. Current examples of blockchain remittance banking are Ripple, a blockchain startup (Rella, 2019) and Chinese Merchant Bank (CMB), which has been adopting blockchain direct payment to improve the speed and efficiency of cross-border payment (Jiang and Chiang, 2022). The technology allows

24-hour to instant payment transfer. One might argue that blockchain technology is still in development and doubt the ability for blockchain to succeed in the remittance industry for countries in turmoil like Myanmar.

Especially for Myanmar migrant workers in Thailand, 94% of them use informal remittance (Bank of Thailand, 2022). Informal remittance in Thailand can be dated back to the 1820s. At the time, Chinese Teochew immigrants from the Southern part of China used Qiaopi or Teochew Letters. The Teochew diaspora in Southeast Asia sent the letters accompanied with remittances to their home (Liu and Zhang, 2020). Nowadays, the letters evolve into a new system for cross-border trades and remittance transfer between Myanmar and Thailand. The system is called Hawala—to transfer or trust in Arabic language. Initially present in South Asia and the Middle East, Hawala became globally popular amongst developing countries. The process starts with a migrant worker finding a Hawala broker or Hawaladars in the area and handing in cash remittance to a Myanmar broker in Thailand. The broker then calls another broker in Myanmar to distribute the remittance to the migrant's family (Bank of Thailand, 2022). From this process, the remittance flow does not transfer actual remittance from Thailand to Myanmar, but rather accumulates cash on each side of the countries.

Figure 1.



As a part of the Hawala process, the broker charges a significantly higher transfer fee at the 2.5 percent compared to the 0.25 percent at the bank (Bank of Thailand, 2022). Why would a migrant worker choose Hawala over a formal method when Hawala's fee is much higher? The market for remittance transfer between Myanmar and Thailand is oligopoly. There are a few brokers in the system; each has a pricing power to set higher transfer fees. The formal financial

institutions face a high barrier to entry as it is a long-standing informal transfer method. For a migrant to choose a transfer method, other than the transaction fee, "the accessibility of the payment points in recipient countries and attributes of migrant workers such as legal status, educational attainment and financial literacy (Kubo, 2015)" involve a migrant worker decision making. The factors result in the migrant workers finding the Hawala system more accessible as 1) it has been in place for a long time, every migrant uses it; 2) the broker also speaks the same language as they do; and 3) it requires no documentation. Therefore, the proposed blockchain-based remittance platform keeps these benefits from the Hawala system, while ensuring security, poses fair transfer fees, and considers the current state of the banking system in Myanmar.

A concern over introducing a new technology is the costs for running the remittance platform. The costs will be marginally high at the beginning because of the user's behavior. The proposed platform offers a referral program, where a user can invite their friends to join the platform and if the friend initiates a transfer on the platform, the user and their friend will receive an amount of money from the platform. Integrating the referral program to attract new users to join the platform can be costly at the beginning. On the other hand, the users will face a fixed cost on learning a new technology and navigating the platform. Besides, the blockchain technology will reduce the intermediary fees associated with cross-border payment (Shin, 2019). The users do not need to pay an overpriced fee in order to initiate a remittance transfer. To examine the plausibility of the blockchain-remittance platform, the principal-agent models guide through the mechanics behind the success of the platform.

III. Theoretical Model and Analysis

The following principal-agent model allows the evaluation on how the platform improves the migrant workers' remittance transfer experience. The principal's model shows the profit maximization function from the platform owner's point of view; it captures the benefits and the costs of running the remittance platform. In the agent's model, it represents a utility function of a Myanmar migrant worker. The worker would like to maximize their total amount of money reaching their family relatives in Myanmar, which would be the main factor deciding whether they are going to join the platform or not.

Principal's Model:

$$\max_{O,R} M(T(x(e(d,B),R))) - A(O,R,W) \quad (1)$$

M = The amount of remittance transfer
T = The amount of trust in the blockchain-based remittance platform
x = The number of words spread on the use of platform from fellow migrant workers
e = The ease of using the platform
d = The number of documents required to register an account on the platform
B = If there is a Burmese language interface option on the platform or not
O = Outreach cost to each migrant workers
R = The amount of free money received from referring a friend to join the platform
A = The total advertisement costs
W = The number of fellow migrant workers (friends) on the platform

Agent's Participation Model:

$$\max_{M,x} \alpha(M,F,t,R) - uE\left(M, W\left(T(x)\right), e(d,B)\right) - \vartheta(H,T(x,R)) \quad (2)$$

α = The total amount of money reaching recipients
F = The percentage of remittance transfer fee for each transaction
t = The amount of time for remittance to be delivered to the recipient
u = If the migrant worker decided to join the platform or not, or if it is their first time using
E = The effort in learning a new blockchain-based remittance platform
ϑ = The opportunity cost of remittance on the blockchain-based remittance platform
H = The value of a trusting relationship with a Hawala broker

Binary Model:

$$\max_{u\in 0,1} uE\left(M, W\left(T(x)\right), e(d,B)\right) \quad (3)$$

As mentioned in the literature and industry review section, the main costs on the platform wner are advertising costs. The owner incentivizes migrant workers to join the platform through the referral program, determined by the amount of free money received from referring a friend to join the platform (R). If a migrant worker joins the platform they will be rewarded an amount of money once they refer another migrant friend and the friend transfers money. The referral program acts as a tool to increase the spread of the words (x) about the platform to the fellow migrant workers, W. The costs are marginally higher in the beginning of launching the platform as not many migrants are expected to transfer remittance on the platform.

The agent's model displays the decision making of a migrant worker whether to join the remittance platform and spread their words about the platform. Constructing a trusting platform can be difficult for the migrant workers who have little to no foundation on digital literacy. Hence, the model takes into account a fixed cost referring to the effort of learning a new blockchain based remittance platform, E. After the friend of a migrant worker receives the referral program money, R, the friend can only use the money as a part of the next remittance transaction. This mechanism forces the friend to use the platform again to utilize the free money they received. By the second time that they succeed in remittance transfer, they do not have to bear the cost of effort in learning a new technology (E).

The change of remittance method can affect the opportunity cost of remittance transfer on the platform (ϑ). As the Hawala system has been in place within the migrant community for a long time, the Hawala broker is a person whom migrant workers trust. In contrast, the blockchain remittance platform is a trustless-trust (T) platform where its purpose is to eliminate the intermediaries (Werbach, 2019). If a migrant worker no longer renounces with a broker, the relationship between the broker, H, and the migrant phases out.

IV. Elasticity and Empirical Analysis

One might ask why we even bother interrupting the Hawala broker's business. Migrant workers involuntarily accept the higher transfer fee in the sacrifice of their finance and technological literacy. A survey in New Zealand on remittances transferred to Tonga reveals that the remitter's amount of money to send back home is inelastic to the transfer fee (Gibson et al., 2006), meaning the necessities of money sent home are highly essential for family survival. The transfer fee is a negative-cost elasticity, which "also suggests that a money transfer operator who lower costs is likely to experience an increase in remittance volume from existing customers (Gibson et al., 2006)." The Hawala remittance methods confounded Gibson's finding; even with a higher transfer fee, migrant workers are stuck with the broker. The relationship suggests an inelasticity in the tendency to change their remittance method and transfer fee. However, the platform's referral program aims to incentivize the migrants' change in the remittance method. One might ask why we even bother interrupting the Hawala broker's business.

Firstly, the current trust in the Hawala broker system valued by the migrant workers are lower and more elastic than one might expect. The survey of Chinese migrants between 2015-2017 shows that the income elasticity of demand in migrants is 0.67 (Cheng and Yin, 2020). The free money from referral program, R, increases the total amount of remittance a migrant worker can send back home, α. The additional money results in a higher tendency to change their remittance method to the remittance platform from Hawala broker. In figure 2, the lower value of a trusting relationship with a Hawala broker, H, decreases the opportunity cost of remittance on the platform, ϑ. The elasticity between the opportunity costs and the trust in the remittance platform is $\frac{\delta\vartheta}{\delta T} > 0$, but not as much as one might argue.

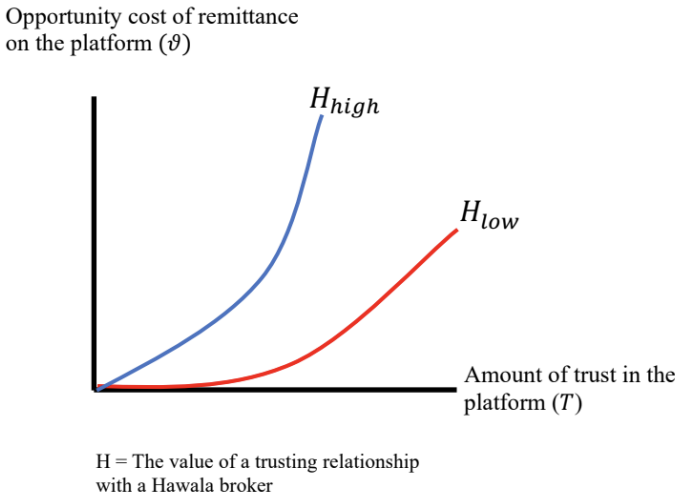


Figure 2: The elasticity curve on the opportunity cost in Equation (2)

Secondly, the referral program in the platform influences the elasticity of the amount of trust in the platform, *T*, and the spread of words on the use of platform, *x*, to be positive and large. The referrals encourage migrant workers to tell their peers to join the platform to receive the free referral money, *R*. In figure 3A, the elasticity curve is exponential. The beginning period has a low number of words spread on the platform, x, the elasticity is near zero $\frac{\delta T}{\delta X} \approx 0$. Meanwhile, when more migrant workers join the platform (W) and more words are spread about the platform (x), the elasticity is positive and large $\frac{\delta T}{\delta X} \gg 0$. The elasticity near zero at the beginning of platform launching ($\frac{\delta T}{\delta X} \gg 0$) is a drop in the bucket problem. To solve the drop in the bucket problem, the platform owner implements the referral program as an exogenous variable in the agent's model that will rotate the curve in figure 3B upwards (from R_{no} to R_{yes}). The platform with a referral program results in a more responsive behavior for migrant workers to trust the platform after hearing about it from others, $\frac{\delta T}{\delta X} \gg\gg 0$.

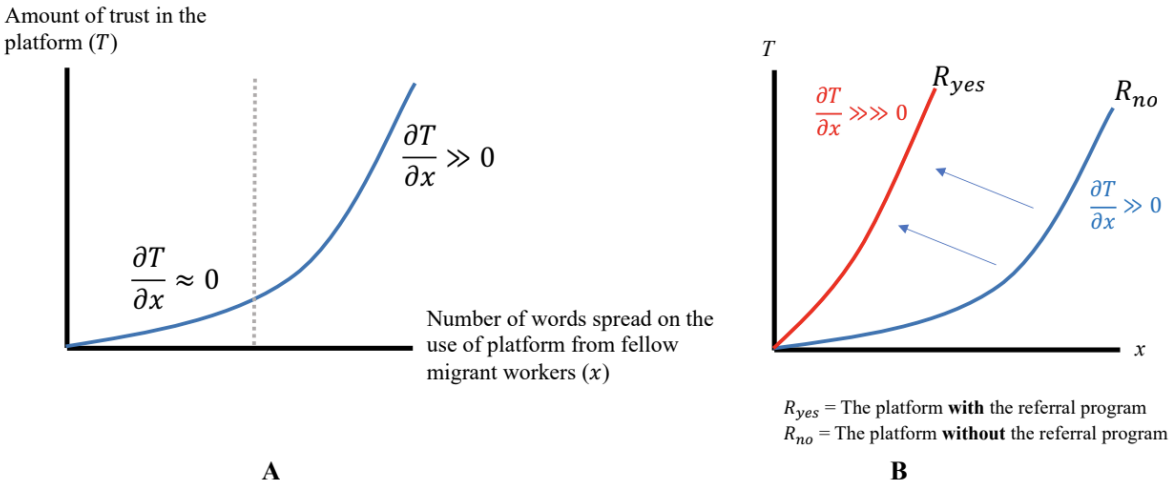


Figure 3AB. An elasticity curve between the trust in the platform and the words spread about the platform

Another approach to solve the drop in the bucket problem is through a game theory matrix. A migrant worker may choose to tell other migrant workers about the platform or not, while other migrant workers may accept the referral invitation or ignore it. A game theory matrix below shows the payoffs that all migrant workers will receive the most utility if a migrant worker chooses to tell other migrant workers about the platform and then accepts the referral invitation. Thus, the worrisome of whether the migrant workers will tell other migrants about the platform is no longer an issue.

		Other migrant workers	
		Accept the invitation	Ignore the invitation
A migrant worker	Tell others about the platform	$5 + \varepsilon\ ,\ 5 + \varepsilon$	$15 + \varepsilon,\ 15$
	Keep the platform to themselves	$10,\ 10 + \varepsilon$	$20,\ 20$

$where\ \ \varepsilon = 15$

Figure 4. A game theory matrix shows the payoffs between a migrant worker and the other migrant workers

Lastly, the sustainable and long-term incentive for people joining the platform expands further than the referral invitations. The migrant workers, who may not have immediate friends

to refer them to, will join the platform voluntarily as they see the expected utility from seeing other migrant workers on the platform. Based on an empirical framework from Besley and Case (1992), the knowledge about the new blockchain-based remittance platform can be considered a public good. A migrant worker, *i*, at the time, *t*, has knowledge about the platform, k_t^i Suppose the knowledge is a public good, $k_t^i = k_t$. When a migrant worker realizes that other migrants are joining the platform, they develop an expected gain from learning about the knowledge on the platform (Equation 4). The expected gain from seeing other migrants on the platform drives the urge for a migrant worker to contribute to the public good, joining the platform and spreading the words.

$$\pi_{it}^{*} = k_t^i(N(x)) - E\left(W(T(x))\right) - \vartheta(H, T(x)) \quad (4)$$

where $N = \sum_i x_i$

π = The expected gain from joining the remittance platform for a migrant worker
k = The value of knowledge about the remittance platform to a migrant worker
N = The total sum of all migrant workers contribution in joining the platform
x = The number of words spread on the use of platform from fellow migrant workers
E = The effort in learning a new blockchain-based remittance platform
W = The number of fellow migrant workers (friends) on the platform
T = The amount of trust in the blockchain-based remittance platform
ϑ = The opportunity cost of remittance on the blockchain-based remittance platform
H = The value of a trusting relationship with a Hawala broker

In addition to knowledge about the new remittance platform as a public good, the security of migrant workers' lives also depends upon the use of the platform. The hawala system has a negative connotation associated with it. Many brokers take advantage of the governmental loophole and use the Hawala system to cover up money laundering and illegal trades cross-border (de Bunt, 2006). The platform hopes to eliminate the broker who is taking advantage and make the migrants at a security risk. Because the platform can be a flop due to forecasted negative returns at the beginning of the platform launch (referral program), many migrant workers need to join the platform for the platform to be profitable. Otherwise, they will just bounce back to the Hawala system—contributing to the perpetuated unsafe cycle. The Myanmar migrant workers already are facing tremendous unfair treatment from Thai employers due to their limited knowledge of the language and legal rights (Campbell, 2012). The platform

with a referral program, hence, offers more than just monetary benefits to the migrant worker—safety and security.

V. Conclusion

The principal-agent models help examine the success of the blockchain-based remittance platform for Myanmar migrant workers in Thailand. The transition from the Hawala broker system to the platform is difficult at first as migrant workers do not have prior trust in the digital remittance platform. The embedded referral program where migrant workers receive money from the platform upon their invited friend's first transaction incentivizes more migrant workers to join the platform and strengthens trust in the platform. The referral program also serves as a drop-in-the-bucket solution for the platform owner.

In hopes to increase the safety and security of migrant workers' remittance process, the platform utilizes blockchain technology in the remittance method. As it is a relatively new technology and an intersection between two industries, there is room for improvement. The proposed solution incentivizes migrant workers to join the platform. However, further research and launch of the platform in each country may need to rely upon the existing banking system in order to effectively use cryptocurrency as a medium of remittance.

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Legal Origins or Institutional Structure? Explaining the Nordic Paradox

Bergen Senf

I. Unbundling Legal Origins Theory

Considerable scholarship has been devoted to the comparative study of legal origins theory following the seminal contribution of La Porta, Lopez-de-Silanes, Shleifer, and Vishny (LLSV) in 1997, which made the initial observation that differences in the outcomes of financial systems are related to a country's legal origin. Over the following two decades a voluminous literature has developed on the relationship between legal systems and economic growth. Legal origins theory broadly characterizes legal systems as belonging either to the English-common law or French-civil law families (La Porta et al. 1998, Glaeser and Shleifer 2002). This is due to a general agreement that historical legal origins, introduced to various states through conquest and colonization, have persistent impacts on a country's legal rules (La Porta et al. 2008).

A great number of authors have made the argument that empirically, common law systems better promote economic development in comparison to civil law systems. Differences in outcome tests are attributed to the distinctive features of the two systems. These characteristics developed due to the differences in the balance of local versus centralized power in the respective contexts in which the two legal systems evolved. Civil law systems rely on extensive codification, written records, and professional judges in an inquisitorial system of dispute resolution. Codification in the context of the legal origins literature means the reliance on specific "bright line rules," that allows for greater conformity of individual judicial decisions to the statutory standard (Glaeser and Shleifer 2002). In contrast, common law systems are decentralized, where broad legal principles are applied to specific fact situations by lay judges who assess oral arguments in an adversarial method of litigation. Common law utilized ex-post enforcement, meaning that regulations are not established until after a market failure or contract breach occurs (Narayanan and Lee-Makiyama 2020). Laws are therefore made by judges in resolving specific disputes that create precedent and are subsequently codified through the legislature (David and Brierley 1978). These base features constitute primary differences between the judicial and law making structures in common and civil law.

Applying LLSV's original claim, successive research has utilized legal origins theory to explain variance between common and civil law for a number of outcomes related to economic development including the size of investor protection, the size of capital markets, procedural formalism, judicial independence, regulation of entry, and corporate and securities law (Kim 2009). Civil law countries have been shown to exhibit "heavier regulation, less secure property rights, more corrupt and less efficient governments, and less political freedom than common law countries" (Glaeser and Shleifer 2002). Many authors have stressed the use of precedent to respond to behavioral innovations as an "adaptability channel" which allows common law systems the "state capacity" to reform the existing legal structure (Malmendier 2009, Ang and Fredriksson 2018, Engert 2009). Beck et al. (2003) has shown that French civil law's use of comprehensive and rigid legal codes prevent jurisprudence from evolving with economic conditions. Similarly, others have emphasized how legal traditions affect "political structures," and argue that civil law countries less effectively constrain the state, protect property rights, and maintain independent judiciaries (Beck and Levine 2005). Thus, legal origins are hypothesized to create a number of differences in the factors that influence economic development.

However, extensive critiques have been leveled against legal origins theory. While useful for linking legal systems to economic outcomes, the exact means by which legal origins influence institutional quality, regulatory decisions, and enforcement mechanisms remains somewhat unclear (La Porta and Shleifer 2008, Dam 2006). This is largely due to the methodological challenges and the high degree of convergence observed between common and civil law systems (Pejovic 2001, Fairfax 2009), which has made the logic linking legal origins directly to financial outcomes not so clear cut (Cappiello 2010, Engert 2009). Furthermore, little inquiry conducted in the case of hybrid systems, which borrow traits from both common and civil law, and the influence of legal origins on factors not directly related to financial systems has left many questions unresolved (Kim 2009). As argued by Roe (2006), "Differences in legal origins probably were never strong enough to explain differences in financial development well. Common law systems regulate and legislate, as do civil law systems." Legal origins theory must be examined more thoroughly in order to hold direct causal force.

In one of the few papers that relate legal origins explicitly to factors beyond investor protection and property rights, Glaeser et al. (2004) finds that judicial independence and

constitutional review are associated with greater economic freedom, thus accounting for some positive common law outcome effects. The same study notes that French legal origin countries have a lower level of constraints on the executive. Cross (2007) agrees with these observations in finding through an examination of common law processes that legal corruption and legal predictability can be explained by differences in judicial independence. A number of papers have examined the role of codification, with Garoupa and Morriss (2012) going so far as to argue that "attention to these elements would provide a better focus for comparison of legal systems than the formulaic identification of systems as common or civil law." The connection to economic development is especially salient, since the primary areas of law in which codification applies are corporate law and civil litigation (Djankov 2008, Beck and Levine 2005). In contrast to considering the high transaction costs of changing from one aspect of common or civil law to another, Djankov et al. (2003) shows that an appropriate choice between public and private market enforcement should be made considering the context of an industry and level of public accountability and transparency in a country. The aforementioned studies more granularly observe traits that are theorized to differ between common and civil law systems, but fail to explain how such features are produced by a country's legal tradition.

II. Examining the Nordic Paradox

The case of the Nordic countries of Sweden, Norway, Denmark, and Finland present a paradox: Scandinavian legal systems are considered civil law systems, yet achieve both enviable social welfare and economic development outcomes. In legal origins theory analysis, Scandinavian law has simply collapsed within the civil law family, or in some cases is omitted from studies entirely (Zweigert and Kötz 1998). The little attention paid to Scandinavian legal origins is interesting, given that Nordic countries have persistently outperformed civil law countries in economic development measures, such as GDP per capita, and more holistic indicators, including the OECD's Better Life Index. Even more surprising, Nordic countries often top the United States, the United Kingdom, and other common law systems in these rankings. Many in the social sciences and popular reporting have attributed Nordic success to egalitarian values, societal homogeneity, natural resource wealth, and cultural norms of practicality and openness (Martela et al. 2020). However, these surface level observations fail to explain the resilience of Nordic states through periods of considerable popular discontent and

drastic political change. At very least, the forenamed either offer weak causal leverage in distinguishing the case of Scandinavian states or describe the ends, not the means, by which this phenomena occurs (Thomsen 2016).

The law and economics field has largely neglected the Scandinavian system likely due to the challenge presented for legal origins theory to deliver strong causal conclusions for hybrid systems. Although the literature readily acknowledges the anomaly of the Scandinavian case, no study to date has undertaken a comprehensive examination of the system's unique characteristics. This is interesting, given that comparative law scholars have consistently hypothesized the separation between Scandinavian and French-civil systems to be due to the lack of a general civil code in Scandinavian law (Zweigert and Kötz 1998, Bernitz 2010). In contrast to the French Napoleonic Code's extreme degree of codification, Scandinavian law more closely resembles common law in its utilization of fragmentary statues which are interpreted in light of preparatory works (Juutilainen 2013). This absence of codification in Scandinavian serves as evidence of the pragmatic, realist Nordic understanding of the function of law and facilitates a structural "collaborative-competitive ambidexterity" (Midttun and Witoszek 2019). Having resisted multiple moves toward increased codification, the system is grounded in an ongoing commitment to be accessible and comprehensible for the average person (Pihlajamäki 2004). The absence of codification not only explains the distinct cosmetic and procedural style of the Scandinavian system, but is explored in this paper as a key factor that may explain its economic success.

Taking up the challenge of explaining the Nordic case, this paper seeks to isolate and identify the specific institutional qualities associated with legal structures that carry most weight in influencing economic development outcomes. A number of institutional factors have been selected from the literature to represent the relevant differences between civil and common law systems, including legal codification, security of property rights, corruption, regulatory adaptability, judicial independence, constraints on government powers (executive, judiciary, and legislative), strength of the rule of law, and ease of use of the legal system. Together, these measures constitute a comprehensive list that captures the broad range of institutional features that are predicted according to legal origins theory between common and civil law systems. They also lend themselves to empirical measurement and testing. This is an attempt to produce greater specification than the tests used by the legal origins literature, which has been limited to

simple linear regressions using dummy variables coded to reflect differing legal origins and course proxies for economic outcome measures. While this method has resulted in the consensus of common law's superiority over civil law, the conclusions about the driving mechanisms that explain deviation between the two systems have been limited to theoretical explanations.

III. Data

Three groups of institutional features will be considered for this analysis. First, as a measure for the structural adaptability of a legal system, the ability to challenge regulations and amend a national constitution will be included. This flexibility has been stressed in the literature as a critical means by which a system can accommodate innovation, respond to changing economic conditions, and correct for inefficient legal rules. From the World Economic Forum's Global Competitiveness Index, the indicator for the "Efficiency of Legal Framework in Challenging Regulations" is included. This measure reports survey responses to the question, "How easy is it for private businesses to challenge government actions and/or regulations through the legal system?," with higher values indicating greater ease. From La Porta et al.'s 2004 dataset, the dummy variable "Case Law" is included and indicates whether case law is a source of law in a legal system. Providing a more nuanced picture than simply coding a legal system as common or civil law, this variable represents a broader understanding of precedent.

The second institutional grouping, judicial independence, will have one primary and four secondary measures. The primary measure is the World Economic Forum's Global Competitiveness Index's Judicial Independence Score, where higher values represent greater independence from government, individual, or company influence. In the legal origins literature, judicial independence is connected broadly with economic freedom and considered to be a defining feature of the common law process of law generation by judicial precedent. It is argued that judicial autonomy is necessary for the efficient evolution of the law over time, uninhibited by legislative meddling. Judicial integrity and separation is necessary for an effective regulatory environment. As a secondary measure, the World Justice Project (WJP)'s "Government Regulations are Effectively Enforced" measure for "whether government regulations, such as labor, environmental, public health, commercial, and consumer protections

are effectively enforced" is included. Thinking less systematically, judicial independence also impacts the individual litigant. For individual parties, greater ease of access and availability of options, such as alternative dispute resolution mechanisms, are attractive aspects of an independent and efficient judicial system. To measure the ease of use and the degree of party autonomy in a judicial system, the WJP's "People Can Access and Afford Civil Justice," "Civil Justice is Not Subject to Unreasonable Delay," and "Alternative Dispute Resolution Mechanisms are Accessible, Impartial, and Effective" are utilized. For each of the aforementioned WJP measures, higher values indicate better scores.

Third, methods for constraining government power, both overall and between governmental branches are critical for economic development. The measures of "Overall Constraints on Government Powers," "Government Powers are Effectively Limited by the Legislature," and "Government Powers are Effectively Limited by the Judiciary" are provided by the WJP's Rule of Law Index. From the Integrated Network for Societal Conflict Research (INSCR) Polity5 Project, the variable "Executive Constraints" serves as a measure of "the extent of institutional constraints on the decision-making powers of the chief executive." Higher values indicate greater limitations on executive authority. In the legal origins literature, a few proxies have been used as constraints of government power, and are included in tests as secondary measures: the Heritage Foundation's Property Rights Index, the Heritage Foundation's Freedom From Corruption Index, and serving as measure of the threat of expropriation, the WJP's "The Government Does Not Expropriate Without Lawful Process and Adequate Compensation" indicator. By narrowing this analysis to focus on adaptability, judicial independence, and constraints on governmental powers, the relative importance of institutional characteristics may be tested.

For panel regressions and matching analysis, three controls found in the development literature are used to account for effects on GDP per-capita. From the United Nations World Population Prospects, the measures for Median Age of Population and Survival to Age 65 as a percentage of males are included. To account for a measure of human capital, UNESCO's Institute for Statistics measure for Government Expenditure on Education as a Percentage of GDP is used (Abraham and Mallatt 2022).

The sample of data drawn upon for empirical testing includes a nine-year period ranging from 2013-2021 for one hundred and twenty nine countries. However, different

countries report different years of institutional measures, so each country's time period in the sample varies. The range of time for which coverage is strongest is between 2013 and 2018. The summary statistics for GDP per-capita, explanatory variables, and controls are reported in Table 1.

Table 1: Summary Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Outcome:					
GDP Per-Capita (Natural Log)	1,151	8.7566	1.39426	5.75504	11.8181
Controls:					
Survival Rate to Age 65 (Male)	1,024	81.2438	11.3122	45.885	95.266
Government Spending on Education (% of GDP)	984	4.44654	1.5846	0.53	11.78
Median Age of Population	1,161	29.8643	9.22006	14.3	48.4
Legal Origins:					
English Legal Origin	1,160	0.30948	0.46248	0	1
French Legal Origin	1,160	0.51724	0.49992	0	1
German Legal Origin	1,160	0.14224	0.34945	0	1
Scandinavian Legal Origin	1,160	0.03103	0.17349	0	1
Adaptability:					
Ease of Challenging Regulations	688	3.49955	0.90651	1.21803	5.86372
Case Law as a Source of Law	539	0.56957	0.4956	0	1
Judicial Independence:					
Judicial Independence Score	798	3.92455	1.28782	1.11301	6.81848
Effectiveness of Regulatory Enforcement	882	0.53363	0.14102	0.22	0.88
Access and Affordability of Civil Justice	882	0.54441	0.11088	0.22	0.85
Civil Justice Not Subject to Unreasonable Delay	882	0.4594	0.1756	0.06	0.95
Access and Effectiveness of ADR Mechanisms	882	0.65922	0.11932	0.22	0.97
Due Process and the Rights of the Accused	882	0.514	0.18039	0.17	0.93
Constraints on Government Powers:					
Overall Constraints on Government Powers Score	882	0.56574	0.16357	0.17	0.95
Government Powers are Limited by the Legislature	882	0.6019	0.16684	0.05	0.97
Government Powers are Limited by the Judiciary	882	0.54193	0.18312	0.12	0.96
Polity 5 Measure of Executive Constraints	699	5.44206	3.90841	1	7
Property Rights Index	1,154	51.4263	22.5327	5	98
Government Does Not Expropriate Unlawfully	882	0.57689	0.16151	0.14	0.94
Freedom From Corruption Index	1,157	44.599	20.8572	7	97

IV. Approach

The rest of the paper is arranged as follows, with the empirical analysis presented in four stages. Section five presents the results of a simple linear regression of the primary outcome variable, GDP per-capita, on LLSV's original coding for common and civil law systems. Next, civil law is disaggregated into French-civil, German-civil, and Scandinavian origins. Section six uses a fixed effects model to assess the relative weight of institutional characteristics in influencing economic development. Section seven employs a matching method where each legal origin (English-common, French-civil, German-civil, and Scandinavian) will be regressed individually on all primary and secondary institutional factors that are considered in the literature to explain variation between legal traditions. The matching process allows for the

identification of the specific institutional features that are most associated with specific legal origins. Section eight discusses the implications of these findings for legal origins categorization. Section nine concludes.

V. Results

A. Legal Origins: Common and Civil Law

The results from the simple regression presented in Table 2 compare the effect of common and civil law on GDP per-capita. With the application of appropriate controls, the significant result affirms LLSV's original conclusion that common and civil law origins result in different empirical outcomes for GDP per-capita. Under this simple model, civil law systems have a predicted 52.40% lower GDP per-capita than common law countries. This finding affirms the consensus in the literature.

B. Legal Origins: English-Common, French-Civil, German-Civil, and Scandinavian Law

Disaggregating Scandinavian law from the civil law family, the differentiation between French-civil and German-civil law becomes more pronounced with 56.22% lower GDP per-capita than common law countries. Noticeably, the coefficient for Scandinavian law is positive, indicating that Nordic countries have even higher GDP per-capitas than common law systems. The second model better explains variation in GDP per-capita.

Table 2: Legal Origins

	1	2
Variable	**GDP Per-Capita**	**GDP Per-Capita**
Civil Law	-0.4214***	
	(0.0521)	
French and German Civil Law		-0.4461***
		(0.0528)
Scandinavian Law		0.3885***
		(0.0791)
Survival Rate	0.0423***	0.0423***
	(0.0044)	(0.0043)
Spending on Education	0.0946***	0.0657***
	(0.0147)	(0.0151)
Median Age	0.0888***	0.0865***
	(0.0045)	(0.0044)
Constant	2.5474***	2.727***
	(0.2450)	(0.2398)
Observations	951	951
R-squared	0.7827	0.7922

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VI. Institutional Characteristics

Multiple empirical approaches were used for analytical robustness. Due to the limited time period of the sample, it is difficult to discern whether country-specific effects exist. If country-specific effects do not exist, a pooled OLS estimator provides consistent and efficient estimates of parameters. However, if fixed effects exist, a simply pooled OLS estimator returns biased estimates. To test for the suitability of a random effects model, the returns from Hausman specification test and subsequent Breusch and Pagan Lagrangian multiplier test are reported in the Appendix. Following the inconclusive results, unrestricted pooled OLS random effects, and fixed effects models are presented in Table 3a of the Appendix. The significance of institutional variables vary somewhat across the three models. The analysis of the following sections will use a restricted fixed effects model that describes the variation in GDP per-capita well.

A. Fixed Effects

The results of the fixed effects model presented in Table 3 provide considerable empirical evidence that validates the selection of institutional characteristics focused on adaptability, judicial independence, and constraints on government powers from the legal origins literature.

Many of the other indicators for adaptability, judicial independence, and constraints on government powers were weakly associated with GDP per-capita, and did not contribute to a better fitting restricted model. This suggests that more nuanced institutional characteristics, such as access and effectiveness of alternative dispute resolution mechanisms may contribute differing economic outcomes, but are not responsible for a large degree of difference. Similarly, little evidence was found for the impact of corruption or unlawful expropriation. Surprisingly, the insignificant relationship between property rights and GDP per-capita deviates from the literature. Legal origins theory often names one of the strongest attributes of the common law system is its greater ability to secure property rights in comparison to civil law. However, when included in a model that controls for a number of institutional characteristics, property rights appears to matter less for explaining differences in GDP per-capita. The relationship for the ease of challenging regulations is also insignificant, but contributes to the model. Without these two measures, the restricted model suffers from a substantial decrease in its explanatory ability.

Looking first at adaptability, the model affirms the importance of this institutional characteristic for economic growth. Case law providing a source of law has the strongest

positive relationship with GDP per-capita. This is notable because the legal origins consider the distinguishing factor between common and civil law to the degree of codification. The prediction from the literature is therefore well supported in this model.

The results of judicial independence measures are more interesting. The legal origins literature argues that regulatory environment and subsequent enforcement is connected closely with perceptions of economic freedom (Beck and Levine 2005). This model affirms that prediction. However, while more effective regulatory enforcement is related to better economic outcomes, positive procedural processes and interactions with the judicial system may be negatively related to GDP per-capita. It appears that a system with greater respect for due process and less unreasonable delays could be beneficial to the functioning of a legal system, but not what positively impacts economic development. This finding provides insight into the results of the matching method that will follow.

The characteristic grouping of constraints on government powers appears to be especially important for variation in GDP per-capita, but in ways that challenge legal origins theory. Interestingly, the relationship between limits on executive power and GDP per-capita did not hold. This finding is particularly interesting, since the legal origins literature considers one of the primary attributes that lead to less optimal outcomes for civil law is an unconstrained executive (Glaeser et al. 2004). The characteristic of a strong executive in civil law systems has been previously suggested as the cause of poor performance of public enterprises and greater levels of state ownership. In this model, the variable for constraints on government powers provided by the legislature was also insignificant, promoting a reconsideration of prior conclusions. It may be that appropriate constraints provided by power delegations to other components of the political system serve as a corrective mechanism. However, limits provided by the judiciary produce a negative effect for GDP per-capita. It may be that a state with a particularly strong judiciary, especially in a civil law system, creates a legal rigidity that cannot quickly adapt to evolving economic conditions. Finally, while the impact for individual governmental branches did not display as expected, overall constraints on government powers carries significant weight in influencing economic outcomes. The effect of constraints on government powers both overall and provided by the judiciary may be dependent upon the context of the system (common or civil). Of the institutional factors included in the restricted model, greater constraints on government powers results in the largest positive increase in GDP

per-capita. Thus, a more constrained state leads to greater predictability and state integrity, which is essential for economic success.

Table 3:

Variable	GDP Per-Capita
Ease of Challenging Regulations	0.0326
	(0.0279)
Case Law as a Source of Law	0.1661***
	(0.0453)
Effectiveness of Regulatory Enforcement	0.4882**
	(02413)
Due Process and the Rights of the Accused	-0.6069**
	(0.2337)
Civil Justice Not Subject to Unreasonable Delay	-0.2948**
	(0.1342)
Overall Constraints on Government Powers Score	0.8529**
	(0.3927)
Government Powers are Limited by the Judiciary	-0.4392*
	(0.2486)
Property Rights Index	0.0022
	(0.0014)
Survival Rate	-0.0047
	(0.0132)
Spending on Education	0.0082
	(0.0320)
Median Age	0.0242
	(0.0257)
Observations	262
Groups	55
R-squared	0.6701

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VII. Matching Institutional Characteristics

A. Matching Institutional Characteristics: English-Common Law

Having now identified the driving institutional characteristics that influence GDP per-capita, these factors can be matched with individual legal origins. The results of regressing each legal origin on the significant institutional factors are presented in Table 4. For English-common law, the ease of challenging regulations displays as predicted with a strongly significant positive coefficient. In line with this finding, the importance of case law as a process for rule generation via precedent necessitates lower levels of constraints on government to be supplied by the legislature. Therefore, common law systems appear more adaptable to accommodate the emerging needs of businesses and correct for inefficient legal rules. There is

a negative relationship between effectiveness of regulatory enforcement and common law systems, which is predicted by legal origins theory. English legal origins countries are more likely to utilize private market enforcement mechanisms, which are either not available or weaker in civil law countries. Again, judicial effectiveness and independence appears to be a weak spot for common law systems as indicated by what appears to be less respect for due process and rights of the accused. However, the relative importance of limits on government power from the judiciary may compensate for deficiencies within the justice system. This model supports the prediction of legal origins theory that a strong judiciary is a defining characteristic of common law. In order for the organic development of rules through case law, the judiciary must be delegated considerable power relative to the executive and legislature. This affords less opportunity for judicial meddling and gives judges the necessary degree of autonomy to make decisions. While this evolutionary process of weeding out inefficient legal rules may be cumbersome, the judiciary is responsible for contributing an important checking mechanism for governmental power. A strong judiciary may lead to greater security of property rights, as indicated in the model. Finally, it may be that with a more balanced delegation of state power in the process of lawmaking and enforcement in common law systems, overall constraints on government may be unduly burdensome. This is suggested by the negative impact for GDP per-capita caused by an increase of overall government constraints. In summary, given the empirical success of English-common law, this profile of institutional characteristics is what matters most for economic development.

B. Matching Institutional Characteristics: French-Civil Law

The matching results for French-civil law are also robust, but indicate in the opposite direction as common law. Unlike the positive coefficients associated with English legal origins, there is a strong negative relationship between ease of challenging regulations and case law for French-civil law. This affirms the consensus in the literature that the highly codified nature of French law and large public sphere makes for greater difficulty in challenging regulations through the legislative process of rule generation. Case law is not a source of law in the French system, and is reflected as such in this matching test. In the adaptability group, the only significant relationship is an observed negative impact from unreasonable delays in the French system. This may be connected to the finding that government powers in countries with French legal origins are not substantially limited by the judiciary. Therefore, the judiciary has less

relative power to other components of the French state. Interestingly, unlike common law, French-civil law benefits from greater overall constraints on government powers. From the literature, one of the commonly suggested pitfalls of the French-civil law system is its overreaching regulatory state that impedes in the market domain (Beck et al. 2003). This finding offers evidence to support the consensus in the literature that the deficiency in civil law that results in poor empirical performance can be attributed to the system's inability to supply key institutional features.

C. Matching Institutional Characteristics: German-Civil Law

German-civil law presents a mixed picture. In this matching test, German legal origins have the fewest associations with the relevant institutional features return than the three other legal origins. While this restricts the amount of specific conclusions that can be drawn about German systems, the results do not challenge the expectations of legal origins theory. In the literature, German-civil law almost always performs better than French, but worse than Scandinavian and English systems in empirical outcomes for economic development. After matching the explanatory variables, the signs of coefficients for German legal origins share the direction of French legal origins for some institutional features, and English legal origins for others. There is only evidence of strong association for two indicators, one in the ability group and the other under judicial independence. Legal origins theory would predict the difficulty in challenging regulations given the large regulatory state characteristic of the German civil law system. However, this deficiency may be balanced out by the German system's ability to deliver the highest positive association with efficiency in civil justice compared to the other three legal origins.

D. Matching Institutional Characteristics: Scandinavian Law

The matching results for Scandinavian law provide unique insight that fills the gap in the literature. First, the direction of the case law coefficient displays is the same as that of common law, not French-civil law, as legal origins theory would predict. This is an important finding, because codification is theorized to be a distinguishing factor between common and civil law. Looking at this model, it is evident that Scandinavian law's lack of codification is a marked difference from French-civil law. The association of case law and Scandinavian legal origins is significant at the 1% level. Therefore, the use of fragmentary statues and reliance on preparatory works function similarly to the English-common law system's process of precedent.

For the other factor for adaptability, the relationship between the ease of challenging regulations and Scandinavian law is only weakly significant. This can be logically predicted as the result of the larger state-capacity exercised through regulation in the Nordic states. With larger regulatory environments and more cumbersome legislative processes in Nordic states in comparison to common law, it is impressive that the coefficient is positive for Scandinavian legal origins. The use of case law as a source of law may overcome the challenges inherent in a larger regulatory state. The relationships for judicial independence and effectiveness with Scandinavian legal origins run in the opposite direction as common law. While Nordic states are not the most efficient in delivering civil justice, regulations are effectively enforced and there is more than sufficient respect for due process. In a system where Nordic governments intrude further in market activities compared to common law countries, an independent and effective judicial system is even more critical. Finally, the measures of constraints on government powers for Scandinavian law are somewhat surprisingly insignificant. While the directionality of the coefficients for constraints on government powers both overall and provided by the judiciary display in line with English legal origins, the model does not suggest that these factors map onto Scandinavian legal origins. However, it does logically follow from the literature that with a larger regulatory domain, property rights may be subject to mild interference. Assessing the matching results as a whole, it appears that Scandinavian countries combine the key elements of common law to mitigate shared traits with French-civil law to achieve successful economic development outcomes.

Table 4: Matching Institutional Characteristics

Variable	English Legal Origin	French Legal Origin	German Legal Origin	Scandinavian Legal Origin
Ease of Challenging Regulations	0.1625***	-0.1396***	-0.0695**	0.0466*
	(0.0362)	(0.0354)	(0.0318)	(0.0282)
Case Law as a Source of Law	0.3519***	-0.4455***	-0.0055	0.099***
	(0.0475)	(0.0524)	(0.0370)	(0.0230)
Effectiveness of Regulatory Enforcement	-0.7831**	0.3277	0.1767	0.2787*
	(0.3303)	(0.3306)	(0.2951)	(0.1473)
Due Process and the Rights of the Accused	-1.2024***	0.5079	-0.1607	0.8552***
	(0.3322)	(0.3304)	(0.2571)	(0.1723)
Civil Justice Not Subject to Unreasonable Delay	0.1766	-0.4825**	0.5264***	-0.2205*
	(0.2027)	(0.2171)	(0.1752)	(0.1159)
Overall Constraints on Government Powers Score	-1.184**	1.5452**	-0.2661	-0.0949
	(0.5478)	(0.6075)	(0.3064)	(0.1514)
Government Powers are Limited by the Judiciary	1.372***	-2.1394***	0.5467*	0.2204
	(0.4080)	(0.4257)	(0.2868)	(0.1576)
Property Rights Index	0.0038*	0.0012	-0.0002	-0.0047***
	(0.0021)	(0.0021)	(0.0017)	(0.0010)
Observations	276	276	276	276
R-squared	0.4375	0.5491	0.1	0.3155

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

VIII. Discussion

Having employed a matching method for the four legal origins, it is apparent that the institutional characteristics of Scandinavian law are more similar to common law than civil law. As originally theorized, the distinguishing feature of Scandinavian law, a lack of codification, is largely responsible for explaining the divergence from French and German systems in empirical outcomes. The impact of codification is not limited to the process of rulemaking or the size of the regulatory burden, but the judicial system as a whole and its relationship with the business environment. Scandinavian legal systems have recognized the significance of this effect, and have repeatedly resisted movements toward codification (Sandström 2007). Committed to an efficient judicial system and dedicated to upholding fundamental rights, these results provide empirical rationale for Scandinavian systems' decision to reject the French-civil system.

Beyond the Scandinavian case, an examination of the specific institutional features that matter for economic development suggests that common law systems better facilitate these characteristics than civil law systems. The distinction between common and civil law is not merely a useful simplification of the two legal traditions, but also an indicator of favorable

institutional arrangements for economic success. For further support for the triumph of common law, Scandinavian law should be reconsidered on the basis of its institutional characteristics instead of its vague Roman-civil historical roots. It is clear that the present state of Scandinavian legal systems more closely resembles that of English-common, not French or German-civil law. If Scandinavian law was regrouped under the common law family in the original legal origins regression, the effect of common law would be more pronounced. As presented as the second model in Table 5, Scandinavian and English legal origins together have an observed 62.57% higher GDP per-capita than the civil law countries included in this sample. From LLSV's coding of legal origins (Model 1), this is a 10% increase in the GDP per-capita difference between common law and civil law.

Table 5: Re-Bundling Legal Origins

	1	2
Variable	**GDP Per-Capita**	**GDP Per-Capita**
Civil Law	-0.4214***	
	(0.0521)	
English and Scandinavian Common Law		0.4860***
		(0.04961)
Survival Rate	0.0423***	0.0428***
	(0.0044)	(0.0043)
Spending on Education	0.0946***	0.0784***
	(0.0147)	(0.0144)
Median Age	0.0888***	0.0874***
	(0.0045)	(0.0044)
Constant	2.5474***	2.1614***
	(0.2450)	(0.2506)
Observations	951	951
R-squared	0.7827	0.7903

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

IX. Conclusion

Upon first examination, the economic superiority of Nordic countries appears paradoxical when Scandinavian legal systems are grouped within the civil law family. At a minimum, Nordic states represent an outlier case in legal origins theory. However, after identifying the specific institutional features that matter most for economic growth, the Nordic puzzle is less paradoxical. Stemming primarily from its lack of a general civil code, the

Scandinavian system produces the same institutional features as common law. This finding prompts a reconsideration of legal origins theory and suggests several areas for future research. If the hybrid Scandinavian system can incorporate the critical mechanisms of common law with a larger and more intrusive regulatory state, it appears that successful convergence between common and civil law systems is possible. This finding was made possible by the use of more precise empirical techniques that could be applied to other questions posed by legal origins theory. Not unlike many previous contributions to the literature, this study is still limited by the available measures for institutional quality and issues with data coverage. Nevertheless, a greater understanding of the driving institutional factors may add a dimension of insight beyond a simple categorization of legal origins

X. Appendix

Table 3a

Variable	Pooled OLS	Random	Fixed
Ease of Challenging Regulations	0.0704	0.0822**	0.039
	(0.0681)	(0.0338)	(0.0275)
Case Law as a Source of Law	0.0041	0.1272	0.1632***
	(0.0692)	(0.0788)	(0.0449)
Judicial Independence Score	-0.0918	-0.003	-0.0051
	(0.0654)	(0.0251)	(0.0283)
Effectiveness Regulatory Enforcement	1.494***	0.6305**	0.5242**
	(0.4842)	(0.2601)	(0.2537)
Access and Affordability of Civil Justice	1.3706*	0.2437	0.1138**
	(0.3464)	(0.2070)	(0.0451)
Civil Justice Not Subject to Unreasonable Delay	0.1296	-0.1077	-0.2804*
	(0.2219)	(0.1519)	(0.1473)
Access and Effectiveness of ADR Mechanisms	1.3794***	-0.029	0.0609
	(0.3400)	(0.1572)	(0.1772)
Due Process and the Rights of the Accused	-0.2864	-0.0636	-0.5779**
	(0.5179)	(0.2232)	(0.2382)
Overall Constraints on Government Powers Score	-0.9315	0.4247	0.5544
	(0.8317)	(0.6993)	(0.5352)
Government Powers are Limited by the Legislature	0.4602	0.4379	0.1985
	(0.4285)	(0.2793)	(0.2038)
Government Powers are Limited by the Judiciary	-0.2122	-0.5694**	-0.4914*
	(0.5394)	(0.2691)	(0.2589)
Polity 5 Measure of Executive Constraints	0.0902***	0.0035	-0.0007
	(0.0342)	(0.0338)	(0.0431)
Property Rights Index	0.0053*	-0.0001	0.0019
	(0.0031)	(0.0018)	(0.0016)
Government Does Not Expropriate Unlawfully	-0.3906	0.0671	0.1314
	(0.4246)	(0.2357)	(0.2274)
Freedom From Corruption Index	0.0120**	0.0026	-0.0008
	(0.0055)	(0.0027)	(0.0027)
Survival Rate	0.0282***	0.0086	-0.0023
	(0.0076)	(0.0109)	(0.0132)
Spending on Education	0.0559*	0.0621**	0.0116
	(0.0316)	(0.0305)	(0.0325)
Median Age	0.054***	0.0956***	0.0272
	(0.0087)	(0.0151)	(0.0237)
Observations	259	259	259
Groups		55	55
R-squared	0.9192	0.8852	0.7511

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Random Effects Tests	
Hausman Fixed-Random	
Chi-squared	56.41
P-value	0.0000****
V_b-V_B is not positive definite	
Breusch and Pagan Lagrangian	
Chi-bar squared	294.15
P-value	0.0000***

*** p<0.01, ** p<0.05, * p<0.1

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